"ENHANCING PRODUCTIVITY OF HIGHER TECHNICAL EDUCATION BASED ON TPM CONCEPT"

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ENGLISH ABSTRACT

In today's competitive world, achieving World-class excellence is a challenge for industries. To compete in today's globalized economy, manufacturers must face stiff competition. It is a daunting task to accomplish the most with the fewest resources and funds available while ensuring superior quality and on-time delivery. Proper production planning and maintenance with zero defects would aid the system's success. Appropriate Total Productive Maintenance (TPM) implementation would lead industries to manufacturing excellence.

The broad objective of the proposed inquiry is to see how the initiative of TPM enables manufacturers to achieve Industrial Excellence. Based on the concept of seven pillars, TPM focuses on reducing losses and enhancing the quality of product and timely delivery. The idea of TPM has raised the standard of industries and help them marching towards industrial excellence.

The effective use of TPM in Industries shows excellent results. TPM, if applied in other sectors, may show excellent results. During the survey conducted in Indian industries regarding the ranking of the TPM pillar, the detailed study and practical knowledge gained directed the author to find the application of TPM pillars in the education sector. The study herewith is conducted to see the implementation of TPM in the education sector (Indian). The use of TPM for grading of the technical institutes to be proposed. It needs to implement the equivalent system in education for the betterment of the students. As major and minor losses in industries, we can identify the lacunas (losses in terms of TPM) in the educational system and suggest TPM pillars for education.

India has a traditional Gurukul Parampara of teaching since ancient age. Kings used to send the prince to learn different techniques to Gurus in Ashrams, usually situated in forests. Along with time, the traditional teaching-learning process has been replaced by digital technology using ICT. However, a lot of drawbacks are also associated with it. Especially if we see the latest employability ratio, it is too weak. If we focus on Technical education, hardly 20% of engineers are employable. These show the need to analyze the system. It is needed to develop a model to examine the education system's stakeholders - students, teachers, employers, parents/society, etc.

The focus is to analyze the shortcomings, drawbacks/problems in the systems and map them with the losses in industries. So that, a solution in the form of a TPM tool is proposed for implementation. The aim is to design the model based on TPM pillars for the education system.

Keywords: *Total Productive Maintenance, Enhancing Productivity, Overall Equipment Efficiency, Total Productive Education, Higher technical education, Sandip University.*

DANSK SUMMARY

I nutidens konkurrenceprægede verden er det en udfordring for industrier at opnå verdensklasse-status. Producenterne står over for hård konkurrence for at klare sig i den globaliserede økonomi. Det er en vanskelig opgave at producere maksimalt med minimale ressourcer og midler til rådighed, mens man samtidig og rettidigt skal levere overlegen kvalitet. Korrekt, fejlfri produktionsplanlægning og vedligeholdelse kan dog medvirke til, at man opnår succes. En hensigtsmæssig implementering af *Total Productive Maintenance* (TPM) vil hjælpe brancherne hen imod optimal produktion.

Det overordnede mål med den foreslåede undersøgelse er at se, hvordan TPM-værktøjet gør det muligt for producenter at opnå optimal produktion. TPM er baseret på et koncept med syv søjler og fokuserer på at reducere tab og forbedre produkters kvalitet samt rettidig levering. Konceptet bag TPM har hævet standarden for industrier og hjulpet dem hen mod optimal produktion.

En effektiv og rigtig anvendelse af TPM i industrier viser fremragende resultater. Hvis TPM anvendes i andre sektorer, kan det også vise fremragende resultater. I løbet af den undersøgelse, som blev foretaget i indiske industrier vedrørende TPM, ledte de detaljerede studier og den praktiske viden, der blev opnået, forfatteren til at anvende TPM-søjlerne i uddannelsessektoren. Undersøgelsen udføres derfor i den indiske uddannelsessektor for at se nærmere på implementeringen af TPM dér. Det foreslås, hvordan man kan anvende TPM i de tekniske institutter. Det er nødvendigt at implementere det tilsvarende system i uddannelsessektoren til gavn for de studerende. Ligesom der er større eller mindre tab i forskellige brancher, kan vi også identificere mangler (eller tab i form af TPM) i uddannelsessystemet og foreslå, hvordan TPM-søjlerne kan anvendes i uddannelsessektoren.

Undervisning i Indien har siden oldtiden fulgt traditionelle Gurukul Parampara-principper. Konger plejede at sende deres kongesønner ud til guruer i Ashrams, som normalt var placeret i skove, for at lære forskellige teknikker. Med tiden er den traditionelle undervisnings- og indlæringsproces blevet erstattet af digital teknologi. Imidlertid er der også mange ulemper forbundet med det, især hvis vi ser på beskæftigelsesgraden, som ofte er for lav. Inden for de tekniske uddannelser er knap 20% af ingeniørerne i arbejde. Disse viser behovet for at analysere systemet. Det er nødvendigt at udvikle en model, hvormed man kan undersøge alle uddannelsessystemets interessenter: studerende, lærere, arbejdsgivere, forældre/samfund osv.

Fokus her er at analysere manglerne, ulemperne og/eller problemerne i uddannelsessystemerne og sammenligne dem med tabene i industrien for at nå frem til en løsning i form af et TPM-værktøj, der kan implementeres. Målet er at designe en model til uddannelsessystemet, som er baseret på TPM-søjlerne..

Nøgleord: Total produktiv vedligeholdelse, øget produktivitet, samlet udstyrseffektivitet, samlet produktiv uddannelse, højere teknisk uddannelse, Sandip Universitet

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According to Indian mythology, "Gurur Brahma, Gurur Vishnu, Gurur Devo Maheshwara; Gurur Sakshat Param Brahma, Tasmai Shri Guravay Namah." Means Guru (teacher) is the lord, the creator, organizer, and destroys all the odds. So my first sincere gratitude goes to my Guru – ***Professor Ramjee Prasad***, Founder President, CTIF Global Capsule, Aarhus University, Herning, Denmark, my supervisor, because of whose blessings I am on this path. My sincere thanks to Prof. Morten Falck, Aalborg University, and Prof. Rajendra Tated, Sandip University, my co-supervisors who continuously guided me in my research work's technical journey.

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LIST OF ACRONYMS

Acronyms	**Abbreviations**
ABL	Activity-Based Learning
AHP	Analytical Hierarchy Process
AICTE	All India Council for Technical Education
AM	Autonomous Maintenance
ARCI	International Advanced Research Centre for Powder Metallurgy and New Material
CI	Consistency Index
CIA	Continous Internal Assisment
CR	Random Index
EMS	Environmental Management System
ET	Education and Training
FMEA	Failure Mode Effects Analysis
FTA	Fault tree Analysis
ICT	Information and communications technology
IFM	Initial Flow Control (Maintenance Prevention)
ISO	International Organization for Standardization
ISRO	Indian Space Research Organisation
JH	Jisu Hozen (Autonomous Maintenance)
JIPM	Japanese Institute of Plant Maintenance
KAI	Key Activity Index
KK	Kobestu Kaizen(Focused Improvement)
KMI	Key Management Index
KPI	Key Performance Index
LCC	Life cycle cost
MCDM	Multi-Criteria Decision Making
MHRD	Ministry of Human Resources and Development
MoU	Memorandum of Understanding
MP	Maintenance Prevention
NAAC	National Assessment and Accreditation Council
NBA	National Board of Accreditation
OEE	Overall Equipment Efficiency
OTPM	Office TPM
PBL	Project-Based Learning
PCQD	Productivity, Cost, Quality and Delivery in Time
PM	Preventive Maintenance
PQCDSM	Productivity, Quality, Cost, Delivery in Time, Safety and Moral
QM	Quality Maintenance
R&D	Research and Development

RI	Random Index
SHE	Safety Health and Education
SIEM	Sandip Institute of Engineering and Management
SITRC	Sandip Institute of Technology and Research Center
SOET	Sandip Institute of Engineering and Management
SPPU	Savitribai Phule Pune University
SUN	Sandip University, Nashik
TPE	Total Productive Education
TPM	Total Productive Maintenance

CHAPTER 1. INTRODUCTION

This chapter describes the research work's context, inspiration, and challenges. As a result, it emphasizes the crucial challenges of implementing Total Productive Maintenance (TPM) in industries and the need to rank the pillars. The need for TPM implementation in the education sector is also justified, defining the research work's objectives. This chapter defines the problem statement and the scope of the research. It outlines research contributions in support of publications—a thesis description given to help readers concentrate and clarify the structure of the argument.

1.1. MOTIVATION AND NEED

The objective of the research is to enhance productivity in higher technical education in India. Industries often use the term productivity, for which the measuring factor is Overall Equipment Efficiency (OEE). Total Productive Maintenance (TPM) implementation helps increase productivity, increasing the industries' efficiency, achieving higher OEE to march towards excellence. TPM is a method for reducing losses and improving efficiency. A similar idea could improve the standard of technical education. The subject addresses the history of TPM as well as the need to enhance professional education.

“TPM strives to achieve perfect production by a holistic approach to equipment maintenance: No breakdown, No stops, No defects, and No accidents.”[1]

The broad objective of the proposed inquiry is to see how the initiative of TPM enables a manufacturer to achieve Industrial Excellence. The implementation of TPM in the industry is not an easy task[2]. Experts take decisions on their experience, involvement, and timely response from management also plays a significant role in in-time decisions. There is a need to understand the TPM pillars and their purpose and contributions to implement TPM successfully. Judgment regarding the stepwise implementation of TPM, with equal justice to all the pillars and support from management in terms of timely decision and funds, is significant for successful implementation of TPM. Otherwise, there are many cases of failure[3]. The basis of TPM is seven pillars and 5S. The research's objective is to express the importance of the TPMs seven pillars compared to each other. Though subject experts can taper out a hierarchy based on experience, the present study aims to quantify the critical pillars numerically. When anything is measurable, it can be controlled and managed better—the main criteria of TPM viz.- Productivity, Cost, Quality, and Delivery in time (PCQD) will be thoroughly studied and compared to Indian industries.

The significance of the above criteria concerning the eight pillars of TPM is to be analyzed. Analytical Hierarchy Process (AHP) is evolving, which can enable decision-makers to represent the interactions of multiple factors in complex and unstructured situations[4][5]. AHP is a multi-criteria decision-making process based on mathematics and psychology using a structured technique for organizing and analyzing complex decisions [5]. By applying AHP, the analysis to be carried out by using paired comparisons of each pillar with objectives. It will help management select the pillars priority-wise and focus their attention on those pillars, which are most important in terms of their potential to increase organizational effectiveness. Based on this implementation's results, the aim is to develop mathematical models to estimate various factors like productivity and value-added per employee to increase Overall Equipment Efficiency (OEE). The case of Indian industries will be considered to formulate TPM pillars in hierarchical order.

Implementation of TPM in industries shows excellent results. TPM, if applied in other sectors, may show excellent results too. Low employability is the problem faced by engineering graduates in India. Considering the technical education scenario in India, we can introduce the concept of TPM in the education sector. The study undertakes to find the application of TPM in the education sector (Higher technical education in India.). It proposes the use of TPM for efficiently reducing the problems in technical institutes. We can suggest the use in identifying and solving problems in the educational system as the TPM pillars primarily function to reduce major and minor losses in industries.

1.2. BACKGROUND OF TPM

Increasing overall equipment effectiveness to achieve a world-class level is possible through Total Productive Maintenance, based on teamwork through people and not through technology or system alone. It involves people from all concerned departments like design, production, quality, finance, sales, purchase, and supervisors and management [6]. A growing number of Western companies are enthusiastically adopting the TPM approach, recognizing that it is a world-class process with measurable benefits. The East is a manufacturing-led initiative driven by production and maintenance with a 50% partnership.

TPM seeks to apply a companywide approach towards achieving a standard of manufacturing performance in terms of the overall effectiveness of equipment, machines, and processes, which is truly world-class. It does not rest at a point but strives for continuous improvement, aiming to achieve and sustain a flawless operation.

There are three particular features in the TPM process:

- It involves methods for data collection, analysis, problem-solving, and process control, aiming to improve equipment effectiveness [7].
- It encourages production engineers, maintenance engineers to work together as equal partners [6].
- It nurtures the continuous improvement of equipment and, in doing so, makes extensive use of standardization, workplace organization, visual management, and problem-solving [6].

Success stories are available for TPM and the failure cases due to barriers. Chapter 2 discusses both the factors in detail. The study focuses on providing a solution for the effective implementation of TPM in Industries by ranking pillars. It proposes to find a similar model in education institutes considering the effectiveness of TPM in industries.

1.3. INTRODUCTION TO TECHNICAL EDUCATION IN INDIA

Globalization has increased competition for industries and educational institutes. Various industrial sectors in India strive to march towards excellence through TPM by achieving world-class manufacturing, whereas educational institutes struggle for student enrollment and employability. The skilled human resources required in industries are missing in the current technical education scenario. To tackle the present problem, skilled and mentally robust human resources are necessary to cope up with technical cum industry work. In this order, to maintain quality, faculty/student ratio, stimulate the eco-friendly environment for students, and support the world's best intellectual, the All India Council for Technical Education (AICTE) was formed under the Government of India.

As per recent reports, 18.86% of students go for technical education as their undergraduate study [8]. Table 1.1 shows the growth of technical institutes in India [9]. A boom in the number of technical institutions for the engineering sector has led to acute issues and concerns. Colleges are trying hard to hire adequately qualified faculty, whereas regulators are under pressure to improve standards, and graduates fail to find employment [10].

Table 1-1: Growth of intake of technical institutes in India (UG), (Source: AICTE)

Year	Engg	Phar	Arch	HMCT	Total	Added in Year
2006-07	659717	76030	5085	5840	746672	30432
2007-08	701214	77582	5189	5959	789944	43272
2008-09	753910	78763	5268	6050	843991	54047
2009-10	1093380	80370	5375	6174	1185299	341308
2010-11	1219347	81594	5457	6268	1312666	127367
2011-12	1386083	83041	6894	6295	1482313	169647
2012-13	1565722	85461	8874	6355	1666412	184099
2013-14	1634596	86444	8614	6520	1736174	69762

The number of technical institutes is increasing while the employability rate decreases, which has affected the student enrollment ratio in technical institutes, as shown in Table 1.2.

Table 1-2: Engineering – Course Vs. Intake, Enrolment, Placement for 'UG' for the AY – 2016-17, (Source: AICTE)

Sr No.	Descipline	Intake	Enrolment	Placement	% Enrolment	% Placement
1	Chemical Engineering	16352	9782	2413	59.82	14.76
2	Civil Engineering	242969	114503	31292	47.13	12.88
3	Computer Science Engineering	372590	226682	97489	60.84	26.17
4	Electrical Engineering	201072	78193	37590	38.89	18.69
5	Electriconics and Communication Engineering	326860	144887	80514	44.33	24.63
6	Mechanical Engineering	371535	176848	70943	47.60	19.09
	Total:	**1531378**	**750895**	**320241**	**49.03**	**20.91**

Table 1.2 & Fig. 1.1 shows the enrollment and placement in engineering branches at the undergraduate level. Enrollment is 49.03% of the intake, and the placement is 20.91% of the enrollment, meaning 67.2% of engineering students are unemployable.

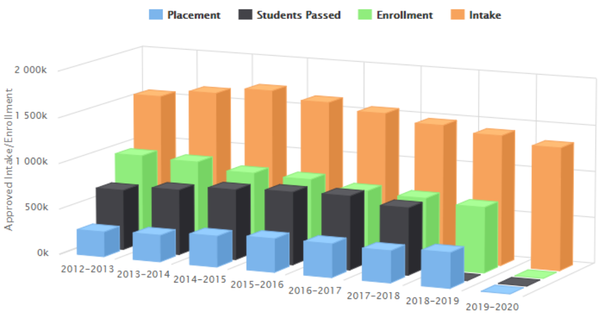

Figure 1-1: Placements for Engineering and Technology 2018-19, UG (Source – AICTE)

Fig. 1.1 indicates the growth rate of the number of technical institutes and their intake compared to the placement available [11].
The grants from the state and the central government are the primary source of funding for public universities and colleges compared to a small percentage of fees. In the Indian education sector, many higher education institutions are underfunded, especially in the technology sector, where labs and classrooms are often under-resourced and understaffed.

Table 1-3: Vacant seats in engineering institutes in India

Type Of Institute	Total Seats	Total Allotted Seats	Vacant seats	%age of empty seats
Govt./Aided Self Finance	1338	1338	0	0
Other University	2280	1856	424	18.59
Govt. Aided College	3017	3017	0	0
Private College	120249	19936	100313	83.42
Total	**126884**	**26147**	**100737**	**79.39**

Table 1-3 gives the position of vacant seats in engineering institutes in India [12]. To discuss the problem of enrollment, we can consider the case of Uttar Pradesh. It has 306 engineering colleges that offer 1.26 lakh seats through the central counseling process in various government-aided, govt aided-self financed and private colleges in 2013. In which many seats were vacant in top engineering colleges, including government institutions. In contrast, the average and lesser-known colleges around 58 in numbers have no seats filled, accounting for nearly 20% of the total colleges. And

187 engineering colleges saw 1% to 20% of total seats filled; collectively, over 245 colleges saw less than 20% admissions [12].
Data shows that private institutions accommodate 97% of the 10,60,000 annual intake of students. The yearly intake of students in all Indian Institute of Technology is 7,500, the National Institute of Technology 35,000, and the rest, i.e., 10,17,500, is accounted for the private institutions. They are highlighting the dysfunctional accreditation process, resulting in the lowering of the quality of engineering education. It is needed to strengthen the process of improving the quality of technical education [8]. Comparing the number of engineers graduating in a year, at different levels for India and the USA, Dr. Rao indicated that only 5% of the Bachelor's degree holders from India go for the Master's degree [13].
In contrast, the corresponding figure for the USA is about 50% [14]. The total Ph.D. degree holders in India's engineering discipline are significantly low compared to the USA. The Indian students should develop competencies by pursuing higher qualifications and opt for research at the international level.
Prime Minister Narendra Modi launched the "Make in India" project in September 2014. The aim was to increase manufacturing in India, generating 100 million jobs by 2022 [15]. A sizeable skilled workforce requirement is supposed to create through this initiative, but considering graduates' quality, graduating from engineering institutes, they are not trained and ready to be employed.
As per the Aspiring Minds survey, an employability assessment firm says that only 19.11% of engineering graduates are employable [11]. The students' overall development is required, thus increasing their knowledge, skill, attitude, and good mental and physical state. It is a challenge for the higher technical institutes to graduate employable students. Technical education imparted to the students in India is lagging, which increases unemployability [16]. There is a gap between the industry requirement and the skillset available in the engineering graduates. The student's psychology regarding the current scenario of Indian technical education is changing, affecting the enrollment ratio in engineering institutes. The technical education institutes face students' enrollment problems, and the rate is decreasing day by day [8]. As per the AICTE report, a reduction of 1,31,540 students is observed in intake for AY 2016-17 as compared to 2017-18. Further decrease in enrollment of 53,481 students for the year 2017-18 [17].
As a researcher, Shinde et al. have attempted to find the root causes of students and staff problems in technical education [18]. Other authors, Sahu. et al. have also contributed to identifying the key factors affecting technical education's effectiveness [19]. Accordingly, the author suggests infrastructure, teaching effectiveness, extra-curricular activities, research & development as the four major factors controlling the effectiveness and proposed the mathematical model quantifying it. Damayanti Sen shared the government's efforts since independence regarding improving the quality of Indian technical education [20]. Many authors described total quality management as the primary tool to enhance the effectiveness, excellence, and efficiency in professional education [21][22].
Revision in policies related to quality education is always the priority of the Indian Government, MHRD, and AICTE. Monitoring bodies like the National Board of

Accreditation (NBA), National Assessment and Accreditation Council (NAAC) are made mandatory to the institutes for evaluation and grading. Despite all this, the institutes are not giving the required facilities and are not maintaining the standard of education. The stakeholders like; students, staff, parents, and employers reveal the ground reality. To improve India's quality of present technical education, Prof. P Rama Rao, ARCI, suggested the need for a policy framework [13].

Facts and figures show that students are not turning to technical education despite the demand for a trained workforce. There is a need to analyze the engineering education system and enhance the teaching-learning process. Many UG students cannot meet the demand of industries without finishing school or additional courses [9].

1.4. RESEARCH HYPOTHESIS AND METHODOLOGY

The literature and case studies demonstrate the development in industries as a result of TPM implementation. However, implementing TPM from the kick-off (beginning) to the end is a difficult task. It takes a lot of practice to get it right. Properly selecting the priorities of the pillars is a tedious task that leads to TPM implementation failure in the industry. The TPM pillar rating would facilitate decision-making and reduce the rate of TPM implementation failure. TPM implementation effectively propels an organization to world-class status, so TPM pillars and tools used in industries produce excellent results. For the education sector, we may propose a similar model.

1.4.1. PROBLEM STATEMENT

TPM, which originated in Japan, had a significant impact on Japanese industries. However, research indicates that implementing TPM in Indian industries is a critical task [23]. Instead of success stories, there are more failures. The aim is to figure out how to boost the success rate of TPM implementation in Indian industries. According to the literature from Indian industries on the barriers to TPM implementation, management decisions play a significant role. Delays in making decisions and releasing funds result in the inability to implement creative solutions. Priorities of operations and weightage of pillars in a quantitative form will assist decision-makers in accelerating decision-making and fund distribution. TPM pillars must be quantitatively analyzed, which can be achieved by ranking them. The research problem identified is the lack of quantitative analysis and hierarchy of the TPM pillars. The research aims to merge the TPM implementation gap identified from the literature survey with an analytical approach by developing an order of importance of TPM pillars.

Skilled human resources are in short supply in Indian industries. Engineering students, on the other hand, are unable to find work. The enrollment ratio of students in technical institutes is decreasing due to low employability. Many institutes are experiencing difficulties as a result of low enrollment. Given the problems with Indian technical education, it is vital to recommend the TPM or an analogous model for the education sector.

The objectives of the study:

1. Using an Analytical Hierarchy Method (AHP) to rank TPM pillars in terms of their significance in contributing to industrial excellence factors such as Productivity, Cost, Quality, and Timely Delivery (PCQD).

2. Using AHP, identify criteria/problems for the education system based on the survey results.

3. To enhance technical education efficiency, build the Total Productive Education (TPE) model for the higher technical education system based on the TPM model.

1.4.2. RESEARCH HYPOTHESIS

The following hypothesis can be stated, taking into account the problem statement:

• The automotive industry prefers the Autonomous Maintenance (JH) pillar, while the chemical industry prioritizes the Safety, Health, and Environment (SHE) pillar.

• The proposed TPM pillar hierarchy would be valid for the chosen sector, and similar findings can be obtained in other sectors.

• The TPM module demonstrates that the education sector, in the form of Total Productive Education (TPE), improves the efficiency of a technical institute.

1.5. PUBLICATIONS

The contributions have been as publications in journals and conference proceedings and are being reviewed in journal papers. The relevant publications are listed below:

A. Journal Publications:

1. **Dnyandeo Dattatraya Shinde**, Ramjee Prasad, "Total Productive Education: Model for Higher Technical Education," Journal of Mobile Multimedia, Vol. 17 1–3, 1–26., 2021, River Publishers.
   DOI: 10.13052/jmm1550-4646.17131

2. **Dnyandeo Dattatraya Shinde**, Ramjee Prasad, "Application of AHP for Ranking of Total Productive Maintenance Pillars," Wireless Personal Communications, Volume 100, Issue 2, May 2018, c,
   DOI: 10.1007/s11277-017-5084-4
   http://link.springer.com/article/10.1007/s11277-017-5084-4

3. **Dnyandeo Dattatraya Shinde**, Shwetambari Ahirrao, Ramjee Prasad, "Fishbone Diagram: Application to Identify the Root Causes of Student---Staff Problems in Technical Education," Wireless Personal Communications, Volume 100 Issue 2, May 2018, Pages 653-664,
   DOI: 10.1007/s11277-018-5344-y
   https://link.springer.com/article/10.1007/s11277-018-5344-y

4. **Dnyandeo Dattatraya Shinde**, Ramjee Prasad, "Triangular model: Ultimate regime to enhance efficacy in Technical education.", Journal of Engineering Education Transformations, Volume 33, No. 4, February 2020, pp -64-69, ISSN 2349-2473, eISSN 2394-1707
   DOI:10.16920/jeet/2020/v33i4/149610

5. **Dnyandeo D. Shinde,** Ramjee Prasad, "Mobile Learning: Transforming Traditional Learning to e-learning," International Journal in Emerging Trends on Technology(IJETT), Volume 7, Issue 2, September 2020, 1600-6, ISSN: 2455-0124 (online), 2350-0808 (print)

B. International Conferences

6. **Dnyandeo D. Shinde**, Ramjee Prasad, "Digital Transformation in Technical Education," 22nd International Symposium on Wireless Personal Multimedia Communications (WPMC), November 24-27 2019, Lisbon, Portugal, pp 1-4
   DOI: 10.1109/WPMC48795.2019.9096089.
   https://ieeexplore.ieee.org/document/9096089

7. **D. D. Shinde**, M. Srivastava, and R. Prasad, "An Initiative to Enhance Productivity in Higher Education (Technical) Using Yoga Which Interconnect Human Mind and Body," 2018 Global Wireless Summit (GWS), Chiang Rai, Thailand, 2018, pp. 190-193, doi:10.1109/GWS.2018.8686558. https://ieeexplore.ieee.org/document/8686558

8. **Dnyandeo D. Shinde**, Manas Srivastava, Ramjee Prasad, "Yog Nidra: a therapy to control human mind and body." International Conference on Emerging Trends in Management, Engineering, Law, Technology, and Science (ICEMELTS-2018), Dec 3 to 5 2018, Sandip University, Nashik, India.

9. **Dnyandeo D. Shinde,** Morten Falch, R.G. Tated, Ramjee Prasad, "Review of Indian Education System," 2015 IEEE 3rd International Conference on MOOCs, Innovation, and Technology in Education (MITE), Oct. 1-2 2015, Amritsar, Punjab, pp – 416-419, DOI: 10.1109/MITE.2015.7375356 https://ieeexplore.ieee.org/iel7/7369420/7375274/07375356.pdf

10. **Dnyandeo D. Shinde**, Morten Falch, R.G. Tated, Ramjee Prasad, "Ranking of Total Maintenance pillars using AHP," Global Wireless Summit, 18th International Symposium on Wireless Personal Multimedia Communications (WPMC'15), Dec. 13-15 2015, Hyderabad, India.

11. **Dnyandeo D. Shinde,** Morten Falch, R.G. Tated, Swetambari Ahirrao, Prachi Shinde, "Identifying Root Cause for Students Problems in Technical Education Using Fishbone Diagram," Global Wireless Summit, 18th International Symposium on Wireless Personal Multimedia Communications (WPMC'15), Dec. 13-15 2015, Hyderabad, India, Special Track – Manufacturing Engineering.

C. National Conferences

12. **Dnyandeo D. Shinde**, V.A. Kolhe, "An AHP Approach for Various Applications Review Paper," National Conference on Recent Trends in Mechanical Engineering RTME- 2013 (Met's Institute of Engineering) pages 89-93

1.6. THESIS OUTLINE

The section describes the thesis's outline with a brief description of the individual chapters with their contributions.

Chapter 2: Literature Survey
Chapter 2 provides context for TPM by conducting a literature review that highlights the contributions of various writers to TPM and its various approaches. TPM pillars are defined, and a structure for effective TPM implementation is addressed. The chapter also discusses industrial losses and the different TPM tools used to minimize them, with examples of tools used and success stories from Indian industries. An overview of the TPM failure due to implementation barriers is also addressed, describing the problem statement for the research. In addition, a discussion highlighting Indian technical education was added, providing an understanding of the criteria for technical education effectiveness. The chapter discusses the issues that have been found and the importance of transferring the principle of efficiency in industrial production to higher education. The research problem is described in Chapter 2.

Chapter 3: Analytical Hierarchy Process -AHP
Chapter 3 discusses the Analytical Hierarchy Process (AHP) that will be used to rank the TPM pillars in order to achieve the research goal. It illustrates how the questionnaire for pairwise comparison of the TPM pillars evolves. The chapter discusses the stepwise implementation method of AHP, as well as the assumptions and novelty.

Chapter 4. Ranking of TPM Pillars
The survey interpretation is presented in Chapter 4. The data used to rate the TPM pillars is examined. It suggests using the AHP to rank the hierarchy of TPM pillars and addresses the ranking constraints and outcomes. The chapter addresses the achievement of the first objective of the proposed report, which is a ranking of TPM pillars.

Chapter 5. AHP in Education
Chapter 5 discusses the requirement of TPM for the education sector. The contributions of AHP to education are summarised, and a discussion about implementing the AHP model for the education sector is held. In addition, the subject develops inputs for the AHP model for the education field. This chapter accomplishes and develops the criteria for assessing the education sector. It suggests a simple hierarchy for issues in the education sector as a foundation for a future TPE model.

Chapter 6. Enhancing the productivity of technical education in India
Chapter 6 goes into detail about the survey and the data that was obtained. It analyses and addresses various concepts, defining problems and proposing solutions using

power laws, probability indices, and so on. The chapter also includes a case study of Sandip University that is relevant to the proposed model, as well as examples.

Chapter 7. Model for Education - TPE

By referring to TPM in industry, Chapter 7 proposes the Total Productive Education (TPE) model for the Indian technical education system. TPM in the industry is similar to TPM in the education sector. The problems in the education sector are similar to the industry losses and various pillars to increase overall equipment quality. It connects the problem-solving tools used in TPM with educational institutions.

Chapter 8. Conclusion and Future scope

Chapter 8 concludes the research work. It discusses the conclusion, future scope along with limitations, novelty, and outcomes of the study.

CHAPTER 2. LITERATURE SURVEY

This chapter provides historical trends and a literature review that includes the contributions of numerous writers and TPM researchers. It details the contributions of researchers from Japan, the West, and India. As a consequence of the literature review, it finds gaps in the existing state of understanding. As a result, it develops the study problem as a result of discrepancies in the literature review.

2.1. TOTAL PRODUCTIVE MAINTENENCE

Total Productive Maintenance (TPM) is a tool to reduce losses and improve Overall Equipment Efficiency (OEE) in the industry, thus marching towards the world-class industry. The chapter discusses the concept of TPM in detail.

2.1.1. BACKGROUND AND EVOLUTION OF TOTAL PRODUCTIVE MAINTENANCE

Seiichi Nakajima of Japan is the father of Total Productive Maintenance. Nakajima visited the USA in early 1963 and was much impressed by the preventive maintenance used by them. He taught preventive Maintenance to Japanese who were using breakdown maintenance to reduce downtime at that time. The use of preventive maintenance resulted in increased productivity; hence, the Japanese called it Productive Maintenance [24]. Quality Circles prevalent in Japan spread Productive Maintenance to other functional areas as well. So it came to be called Total Productive Maintenance. Seiichi Nakajima pioneered this approach in Japan and exerted a significant influence over Japanese manufactures' economic growth from the late 1970s. The achievement of world-class manufacturing performance is essential if companies are to survive against international competition. One vital ingredient of this is highly reliable and consistently operated machines, equipment, and processes. Together with their operators and maintainer, these machines, equipment, and processes are the only direct wealth creators in a manufacturing plant; all other functions such as sales, marketing, design, production control, and finance are the feedback support systems. Optimizing man/machine interface is essential to build a consistent and sustainable environment, and all associated sources of waste are eliminated [25].
The definition of Maintenance in Japan is “Maintaining and improving production systems' integrity through the machines, equipment, processes, and employees that add value.” It contrasts with the traditional role for the maintenance department in the west, i.e., “Fix it when it breaks down” [26][27].

2.2. DEFINITION OF TPM

TPM literature offers several Total Productive Maintenance definitions.

•According to Lawrence: "TPM is the general movement on the part of businesses to try to do more with less." [28]

•According to Blanchard: TPM is "an integrated life-cycle approach to factory maintenance and support." [29]

• McKone, Schroeder, et al.: defines TPM as a program involving all employees from production and maintenance personnel to top management addressing equipment maintenance through a comprehensive productive-maintenance delivery system covering the entire life of the equipment." [30]

• Society of Manufacturing Engineers: defines TPM as "a way of working together to improve equipment effectiveness." [31]

• Robinson and Ginder: define TPM as a "method for bringing about change by a set of structured activities that leads to improved management of plant assets when properly performed by individuals and teams." [32].

• Cooke: defines TPM as having the intention to bring both departments production and maintenance together by a combination of teamwork, good working practices, and continuous improvement." [33]

• Steinbacher and Steinbacher: defines TPM as strategies needed to sustain healthy maintenance [34]

According to Bamber and Sharp, the literature defines TPM by two approaches: the Western Approach and the Japanese Approach, having a significant common practice within the two[35]. Bamber describes the Japanese school of thought represented by Nakajima [36][37], Tajiri, and Gotoh[38], and Shirose [39][40][41]. The Western approach represented by Willmott[42], Wireman[43], and Hartmann [44]. The Japanese Institute of Plant Maintenance (JIPM) promoted the Japanese approach. Seiichi Nakajima is a vice chairman of JIPM and considered to be the father of TPM.

Nakajima's Japanese definition of TPM characterizes five key elements: equipment effectiveness, preventive maintenance, department cross-functioning, the involvement of each employee, and motivation [36].

2.3. TPM FOR INDUSTRIAL EXCELLENCE

Suzuki [45] cites, for example, PQCDSM (Productivity, Quality, Cost, Delivery, Safety, and Moral) improvements for early TPM implementers in Japan.

- P – Productivity.
  The net productivity increased by 1.5 to 2.0 times.
  The number of equipment breakdowns reduced from 1/10 to 1/250 of the baseline.
  Increase in Overall plant effectiveness by 1.5 to 2.0 times.
- Q – Quality.
  The quality improved by reducing the process defect rate by 90%.
  Customer returns/claims reduced by 75%.
- C – Cost: Reduction in Production costs by 30%.
- D – Delivery:
  Reduction in Work in Progress (WIP) up to 50%.
- S – Safety.
  Shutdown and accidents eliminated.
  Pollution incidents eliminated.
- M – Moral: Improvement suggestions by employees increased up by five to ten times.

Tajiri and Gotoh spot that "The actual targets of TPM are fixed more concretely in terms of PQCDSM." [38], Fairchild Semiconductor-Penang Malaysia utilizes TPM as an umbrella program to drive strategic PQCDSM goals' [46]. Gardner provides an overview of TPM's success at the National Semiconductor that is typical benefits gained by many companies. Billions of dollars are saved each month in terms of reducing lost revenue.
More efficient equipment and processes mean fewer new pieces of equipment need to be purchased to meet demand. Early detection of problems means fewer resources spent on major breakdowns and scraps. External auditors and customers are impressed by clean and safe factories that are more enjoyable to work in. Total workforce engagement using the TPM method is a unique way to reduce loss and improve profitability [47]. The Japanese firms demonstrate similar improvements that won the JIPM PM prize between 1984 and 1986 [48]. They reduced the equipment failures from 1,000 per month to 20 per month by applying the PM pillar. Hartmann [44] cites TPM initiatives in the Non-Japanese Plants showing tangible results.
Since its introduction in 1970, TPM has developed over the years. Originally there were five activities of TPM referred to as 1st Generation TPM (Total Process Maintenance). It focused on improving equipment effectiveness or performance only. After a decade in the '80s, there are still opportunities lost because of poor production scheduling practices, even if the shop floor was committed entirely to TPM and the elimination or minimization of the "six big losses." Hence to focused on the whole production process, 2nd Generation TPM (Total Process Management) was developed[49].

Finally, in recent times, it has been recognized that the whole industry should involve all departments with the full potential of the capacity to profit gain and costs reductions. To achieve this, the 3rd Generation TPM (Total Productive Manufacturing) has evolved. It now focuses on the sixteen Major Losses and encompasses the eight pillars of TPM incorporating the 4M's – Man, Machine, Methods, and Materials [49].
The industries may approach TPM in its unique way; most approaches recognize the importance of overall equipment effectiveness to measure and improve it in an environment that promotes continuous improvement to reduce operational and maintenance costs.

2.4. DISCUSSION ON TPM PILLARS

The various activities in Total Productive Maintenance are called TPM pillar activities. Fig. 2.1 shows the pillars of TPM [50]. The base of TPM is 5S. It explains 5S before discussing the pillars of TPM.

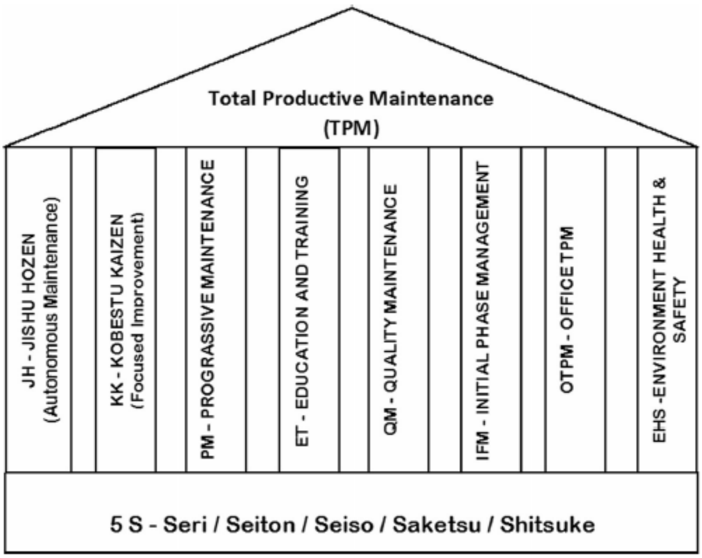

Figure 2-1: TPM Pillars

2.4.1. 5S AND ITS IMPORTANCE

Some authors regard 5S also as a maintenance pillar. 5S is "a systematic approach to organize, order, clean, and standardize a workplace. And to sustain it in the same way. – and keep it that way" [51]. 5S is based on a Japanese technique to establish and maintain an organized and effective workplace.
The elements of 5S include the following explained in Table 2-1 [51] [42].

Table 2-1: 5S Description

5S Steps	Description
Seiri (Sort)	Have a place for each item. Sort and remove an unwanted item.
Sieton (Set in order)	Putting each item in its place.
Seiso (Shine)	Cleaning and maintaining the workplace daily.
Seiketsu (Standardize)	Standardize the procedure for the first three S, and follow it.
Shitsuke (Sustain)	Sustain the process by the following self-discipline.

5S is a valuable and critical element of the TPM process. It isn't easy to assess the economic value of the 5S activity, as it isn't result-centered. They emphasize people's behavioral patterns, such as cleaning and neatening equipment and eliminating unnecessary items from the workplace. Consequently, the activities are making it difficult for the quantitative assessment of their effectiveness [52].

2.4.2. AUTONOMOUS MAINTENANCE (AM) PILLAR (JISHU HOZEN - JH)

The Autonomous Maintenance (AM) pillar brings ownership feelings in the operators. Autonomous maintenance is the process wherein operators accept and share responsibility for their equipment's performance and health, including maintenance[53] [54]. The driving concept of AM is the creation of expert equipment operators for protecting their equipment [40]. AM is the cornerstone of TPM activities [55]. AM addresses the operator perception transition from 'I run the equipment, maintenance fixes it,' to 'I own the performance of this equipment.' The operators are required to have the ability to 'detect abnormalities' concerning the quality of equipment, based on a prediction that 'there is something wrong [54][40]. AM is linked with the Focused Improvement pillar as both pillars support equipment restoration and sustaining primary equipment conditions. "Autonomous Maintenance involves the participation of every operator, each maintaining their equipment and performing activities to maintain its condition and operation correctly.

2.4.3. FOCUSED IMPROVEMENT PILLAR (KOBETSU KAIZEN - KK)

"Focused improvement pillar aims to eliminate losses, maximize the overall effectiveness of processes and equipment. It includes the activities that eliminate losses and improve performance" [45][56]. The objective of Focused Improvement is that equipment to perform at its best every day. The concept of Focused Improvement is *Zero Losses*. Maximizing equipment effectiveness by the elimination of defects and failures, i.e., wastes and losses incurred in equipment operation." [37]. Several tools used to analyze productivity losses in this pillar are:

- 5Why Analysis
- Cause and effect - Fishbone Diagrams
- Fault Tree Analysis (FTA)
- Failure Mode and Effects Analysis (FMEA)
- Pareto Charts
- 5-Why Analysis
- P-M Analysis

Focused Improvement and equipment restoration are not one-time activities. Wear and deterioration occur as a result of the continuous use of equipment. As a result, repairing regular equipment wear is a continuous process over the life of the equipment. [43].

2.4.4. PROGRESSIVE MAINTENANCE PILLAR (PM)

Progressive Maintenance considers design activities carried out for new equipment. It starts with the planning and construction phase. It imparts high reliability, operability, maintainability, economy, safety, and flexibility. It considers maintenance, information, and new technologies. Thereby reducing maintenance expenses and deterioration losses." [39] Maintenance Prevention is also known as Early Management [57], Initial Phase Management [39], and Initial Flow Control [37].
Minimizing the life cycle cost is the objective of the progressive maintenance pillar. It is designed in such a way that there is no breakdown, and maintenance becomes easy. It also aims at the prevention of all losses impacting the effectiveness of the production system. PM design does satisfy reliability, maintainability, Jishu-Hozen, operability, resource-saving, safety, and flexibility [58].

2.4.5. QUALITY MAINTENANCE PILLAR (QM)

"Quality maintenance, in a nutshell, is the establishment of conditions that will preclude the occurrence of defects and control of such conditions from reducing defects to zero." [58]. To achieve Quality Maintenance, establish conditions for zero defects by inspecting and monitoring conditions to eliminate variation, maintaining conditions within specified standards, and executing preventive actions in advance of defects or equipment/process failure. The critical concept of Quality Maintenance is that it focuses on preventive action 'before it happens' (cause-oriented approach) rather than reactive measures ‘after it happens’ (results-oriented approach). (Japanese Institute of Plant Maintenance)[58]. Quality Maintenance builds on the structures developed and fundamental learning within the Focused Improvement, Autonomous Maintenance, Planned Maintenance, and Maintenance Prevention TPM pillars.

2.4.6. OFFICE TPM PILLAR – (OTPM)

Office TPM focuses on improving the efficiency and effectiveness of logistic and administrative functions, hampering manufacturing production operations' performance. Manufacturing alone is not only an essential part of any organization. Administrative and support departments play an important role in supporting manufacturing activities. These departments can improve production effectiveness by proper documentation and by reducing waste [57]. Implementation of the TPM for administration and support departments is similar to continuous improvement in equipment and processes.

2.4.7. ENVIRONMENT, HEALTH, AND SAFETY PILLAR (EHS)

The EHS pillar is equally important as the seven other pillars. Shirose describes safety as “the maintenance of the peace of mind” (Shirose)[39]. Every TPM program has a strict focus on safety, health, and environmental concerns. Eliminating accidents, ensuring equipment reliability, preventing human error, and reducing pollution are the key features of TPM. Suzuki gives examples regarding improving safety and environmental protection [45].
Implementing the TPM EHS pillar focuses on identifying and eliminating safety and environmental incidents. According to the Heinrich Principle, there are 300 ‘near misses,’ 29 injuries, and one death for every 500,000 safety incidents [59].
Ishikawa stated that setting equipment to the most favorable conditions applied to the operations or diagnostic techniques to maintain those conditions requires little attention[60]. Funahashi describes a case study that uses TPM activity to reduce energy consumption in manufacturing [61].
Ishikawa proposes that TPM address the following critical environmental objectives within the Safety and Environmental pillar.[60]

1. Like ISO 14001/14004, it constructs an Environmental Management System (EMS) that integrates environmental issues as a system.
2. Through the TPM program, implement activities to reduce the environmental impact of manufacturing operations.
3. To develop systems to reduce the environmental impact of manufacturing products. Also, process development.
4. Educate the employees to provide them environmental awareness.

2.5. TPM TOOLS TO REDUCE INDUSTRIAL LOSSES

As described in the previous sections, TPM and its pillars increase OEE by reducing losses by implementing various TPM tools. The primary purpose of monitoring losses in the industry is to understand where we are losing quality, time, speed, and ultimately money. After identifying losses, various TPM tools implementation reduce these losses and improve the performance/productivity of the industry.

2.5.1. MAJOR LOSSES IN INDUSTRY

To help identify all losses in a process system (man/material /machine/energy) and thus, eliminate them, they have been divided into 16 categories, as mentioned in Table 2-2.
They can be grouped accordingly, in three categories – 1. The equipment-related losses, 2. The losses relating to human resources and, 3. The losses relating to resource consumption.

Table 2-2: 16 Major Losses in Industry

16 Major Losses in Industry	Description
1. Setup and Adjustment	Setup loss occurs during a changeover between products. Set up time is the time taken to change a process over from the last part of a production run to the first good, repeatable part of the next production run. Adjustment within the setup time is often hidden and involves tweaking settings until it achieves optimal run conditions.
2. Start-Up	After a planned or unplanned shutdown, the loss incurred at the beginning of starting up equipment till steady-state operating conditions occur.
3. Operating Motion	Unnecessary/excessive operator movement and transportation cause poor layout and work that lead to losses.
4. Line Organization	This loss results from a shortage of operators on the line and operators working simultaneously at more equipment than was initially planned.
5. Management	Waiting time losses are caused due to delays in decisions and approval by management.
6. Equipment Failures	Equipment failure loss is due to the breakdown of equipment, causing the function of the line or process to stop.
7. Measurement and Adjustment	Loss is due to frequent measurement and adjustment used to prevent the recurrence of problems.
8. Minor Stops	These are typically minor stoppages not logged as breakdowns and issues causing the machine to pause or idle for short periods. They are often chronic losses, regularly repeated, like loading or emptying the tray or mold. These

	are often not recorded and usually less than 1-minute duration.
9. Reduced Speed	This loss occurs from operating at speed less than the design speed.
10. Defect and Rework	It is the loss of defective product, not confirming the required quality standards, requiring rework, repair, or scrap.
11. Scheduled Down Time	It is scheduled maintenance downtime for machines and equipment as a part of preventative maintenance.
12. Yield	It is the total loss between the input of raw material and the output of finished goods.
13. Energy	Loss of energy in input not effectively utilized leads to energy loss.
14. Tool Die and Jig	It is the cost of the physical consumption of the tools, jig, fixtures, or spare parts or the maintenance of items used on the line.
15. Cutting Blade (Tool) Change	The time loss incurred during swapping of consumable tooling items has become worn/ineffective, or damaged.
16. Logistics	This loss is the wasted time experienced in the incorrect or inefficient delivery of raw materials, packaging, or products to and from the store/factory or the work station.

2.5.2. TPM TOOLS

The section discusses some of the tools used in TPM to reduce losses and improve OEE. It mentions the application of these tools in the education system. Table 2-3 describes few tools used in TPM.

Table 2-3: Tools for TPM

Sr No	**TPM Tool**	**Description**
1	**2-Bin System**	• It is an inventory control system. There are two bins – the first bin is called a working bin and the second bin is supporting. After consuming the first bin, it transfers the material of the second bin and places an order maintaining sufficient stock.
2	**5 Why's**	• It is processed to determine the root cause of a problem. This technique identifies the root cause by asking questions like; why something occurred, why this happened, etc.
3	**5W+2H**	• The continuation of 5Why's was further extended with 2 How's to reach the solution.

4	**5S**	• 5S is the first step implemented, which focuses on cleaning, organizing, and maintaining the workplace.
5	**5G**	• (Gemba, Gembutsu, Genjitsu, Genri & Gensoku): 5Gs are key suggestions for Problem Solving and a method to help elaborate a better description and analysis of phenomena and verify all hypotheses.
6	**8D**	• 8D is an eight discipline tool to identify the root cause of the problem and providing corrective actions to solve the problem permanently.
7	**A3 Report**	• An A3 report is a solution provided on a single A3 size paper sheet, identifying the root cause, providing a solution, and an action plan.
8	**ABC Inventory**	• It categorizes the inventory items into three levels and defines their inventory stock levels. The A items are essential, typically of high volume or high value, B items are moderately important, C items are low priority and generally low volume items.
9	**Acceptance Quality Limit (AQL)**	• AQL is a statistical tool to limit the number of defective items acceptable in a randomly selected sample.
10	**Benchmarking**	• Benchmarking is the process of comparing and setting the best practices in an organization.
11	**Bottleneck Analysis**	• The bottleneck is the analysis tool to identify the critical and blocking step in the process, affecting continuity inflow, acting as a constraint.
12	**Brainstorming**	• It's a problem-solving technique involving team members from all sections, generating and providing better solutions to the problem.
13	**Cause and Effect (Fishbone) diagram**	• It is a root cause analysis tool to identify the causes and their effects on the process. It resembles a fishbone structure.
14	**Check Sheet**	• It is a document to monitor critical elements, which checks them regularly.
15	**Control Chart**	• With the help of Control charts, process stability can be determined and predicted, whether the process is centered.

16	**Cross-Training**	• It is a training process to make the workforce compatible to handle another process within work, in case of an emergency.
17	**CUDBAS**	**Curriculum Development Based on Vocational Ability Structure** • It is the recent tool used for the education and training of the workforce.
18	**Current State Map**	• It is processed to monitor the current state of the process and identify opportunities for improvement.
19	**CLIT**	**Cleaning, Lubrication, Inspection & Tightening.** • CLIT is the process of preventive maintenance.
20	**DMAIC**	**Define, Measure, Analyze, Improve, and Control.** • It is associated with Six Sigma. Before beginning any Six Sigma project, it is necessary to select a process that, if improved, would result in reduced cost, superior quality, or increased efficiency. The process also must possess measurable data because what you cannot measure, you cannot improve. The process selected may currently be experiencing quality problems or generating a large amount of scrap.
21	**ECRS**	**Eliminate, Combination,Reduction & Simplification** • It is a tool for process optimization.
22	**Empowerment**	• It is the tool that particulate the decision-making to the lowest possible level and creating an ownership feeling.
23	**FMEA**	**Failure Modes and Effects Analysis** • It is the process of analyzing failures and their effects.
24	**Flow Chart**	• It represents process flow diagrammatically for better understanding.
25	**Frequency Studies**	• It is a data collection tool by random observation of activity.
26	**Gemba**	• It is a problem identifying technique by visiting at actual workplace.
27	**Horizontal Expansion**	• It is for the organization's expansion, in terms of an increasing number of locations, outlets.

28	**Histogram**	• It is a vertical bar chart based on statistical data, showing the shape of an event's distribution.
29	**Kaizen**	• It is an activity by an individual or a team for continuous incremental improvement in the organization.
30	**Non-value added time (NVA)**	• It is the technique of identifying the activities which do not add value to the process.
31	**One Point Lesson (OPL)**	• It is a training kit for new employees to quickly understand the task and quickly enhance their knowledge and skills.
32	**Overall Equipment Effectiveness (OEE)**	• OEE is the gold standard for measuring manufacturing productivity. It identifies the percentage of manufacturing time that is genuinely productive. 100% OEE means 100% Quality (only Good Parts), 100% Performance (as fast as possible), and 100% Availability (no Stop Time).
33	**Plan Do Check Act (PDCA)**	• It is a cyclic process for continuous improvement.
34	**Pareto chart**	• It is for showing the frequency of occurrence.
35	**Poka Yoke**	• It is a mechanism to make the process error-proof. It prevents mistakes from becoming defects.
36	**Preventive Maintenance**	• It is for regular maintenance to avoid failure.
37	**Scatter Diagram**	• It gives the relationship between interdependent variables used for paired comparison.
38	**Standard Operating Process (SOP)**	• A standard operating process defines routines and procedures for smooth working to prevent errors.
39	**SMART Goals**	**Specific, Measured, Attainable, Realistic, and Timely.** • It is a goal-setting tool for an organization.
40	**Standardized Work**	• It is a processed documenting technique.
41	**Visual Cues / Painted Floor**	• It is to alert everyone regarding the work process and workplace setup. It uses the painting of the floor and marking.

2.6.

2.7. IMPLEMENTATION – TPM IN INDIAN INDUSTRY

The application of the TPM pillars and tools discussed in Table 2-3 is demonstrated below by examining a case study of a company manufacturing automotive components in Aurangabad, India. The section's goal is to demonstrate the impact of implementing TPM tools on performance.

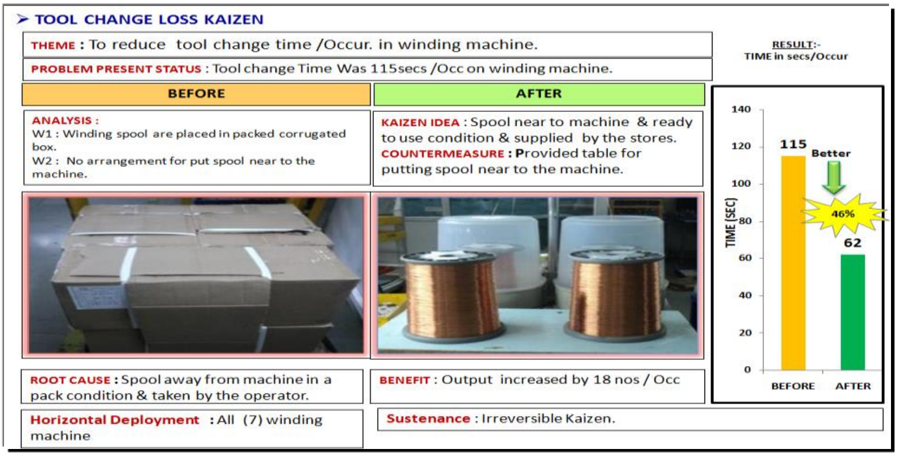

Figure 2-2: Application of Kaizen to reduce Tool Change loss

Implementation of Kaizen tool shown in Fig. 2-2 for the tool change loss for the winding machine. The root cause identified was the tool change loss due to the machine's supply of input raw material—the material provided in packed condition to the operators from the store. It supplies the spool near to the machine in ready-to-use condition from the store. Due to the readily available spool near the machine, the tool reduction in tool change time was noticed from 115 sec/occur to 62 sec/occur (40%).

- **Kaizen**

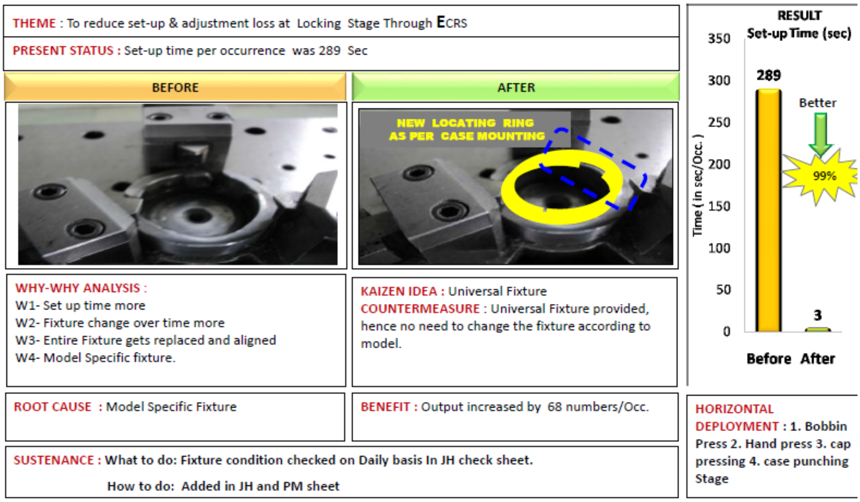

Figure 2-3: Application of Why Why analysis through Kaizen to reduce Setup and adjustment loss

Fig.2-3 shows a Why-Why analysis to identify the root cause of the problem. It also offers the solution provided through Kaizen, reducing the setup and adjustment loss. The problem identified was setup and adjustment time loss during a fixture change, as fixtures available were model specific. Setup time and adjustment time for every fixture change reduce the production. The solution provided was by changing the fixture's design. The universal fixture is provided with locating rings as per a specific model, which can be easily changed, reducing the setup time to change the fixture. It reduces the setup and adjustment time from 289 sec to 3 sec, i.e., 99%, thus increasing efficiency.

Similarly, Kaizen implemented to reduce labor cost as shown in Fig. 2-4. The manual soldering required two labors to change to automatic deep soldering done by a single person with multiple soldering at a time, reducing 75% of human resources hours.

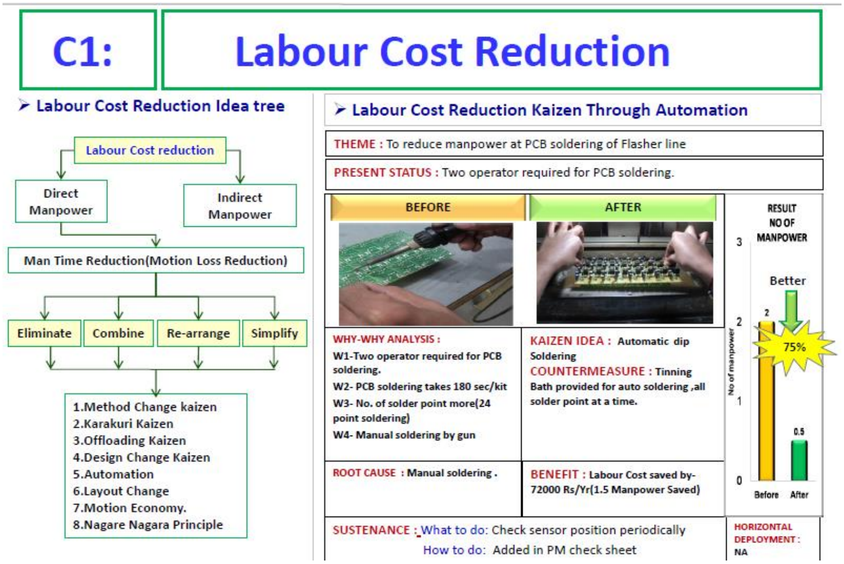

Figure 2-4: Kaizen to reduce Labour cost

Fig. 2-5 shows a reduction in consumable item cost by changing full hand gloves to finger gloves, reducing material cost, and increasing operators comfort, saving material cost by 79.81%.

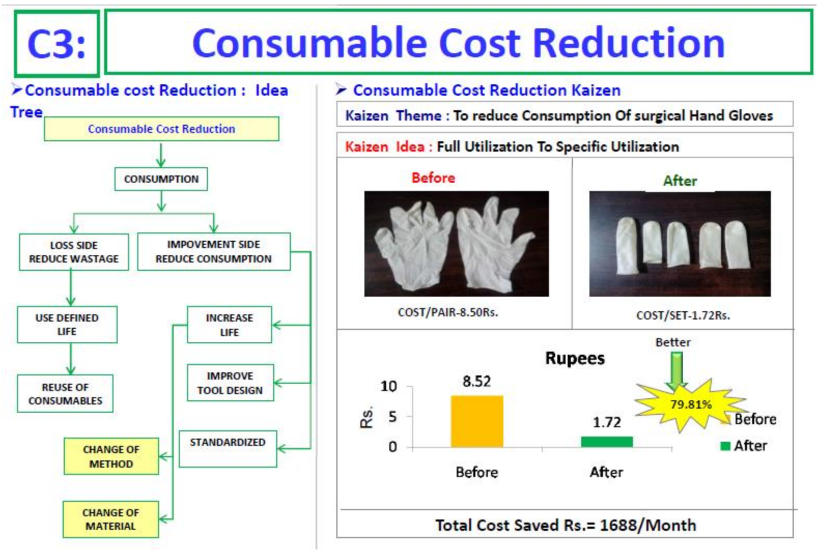

Figure 2-5: Kaizen to reduce consumable cost

2.7.1. OTPM – PILLAR IMPLEMENTATION

Section 2.6 discusses examples of the implementation of TPM tools in various pillars in production-related departments. It also discusses the OTPM pillar's execution related to service departments to showcase the applications for nonproduction departments.

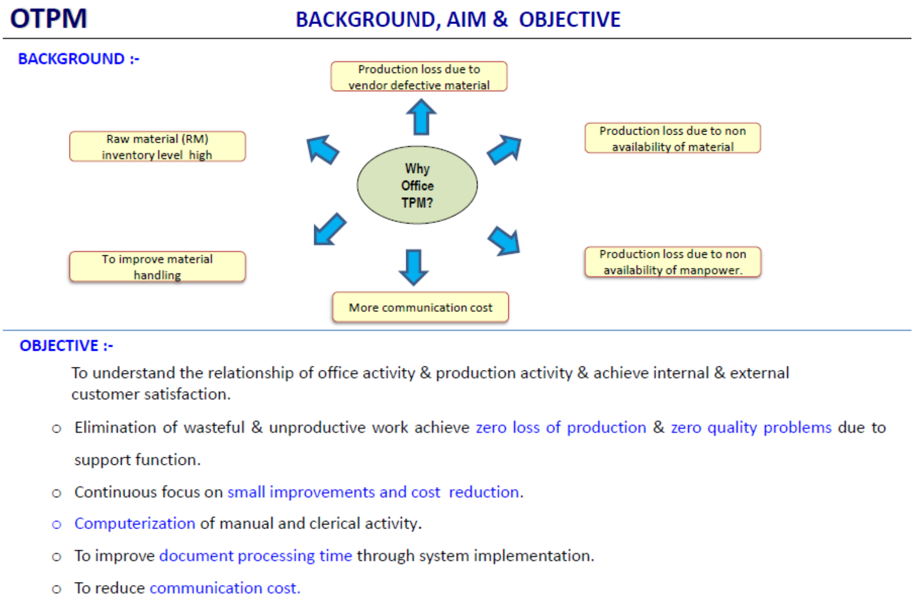

Figure 2-6: Aim for implementing OTPM pillar

Fig. 2-6 shows the aim of implementing the OTPM pillar. The background considered is production loss due to non-availability of material, more inventory cost, more communication cost. It also mentions the pillar objectives to reduce various losses and improve productivity.

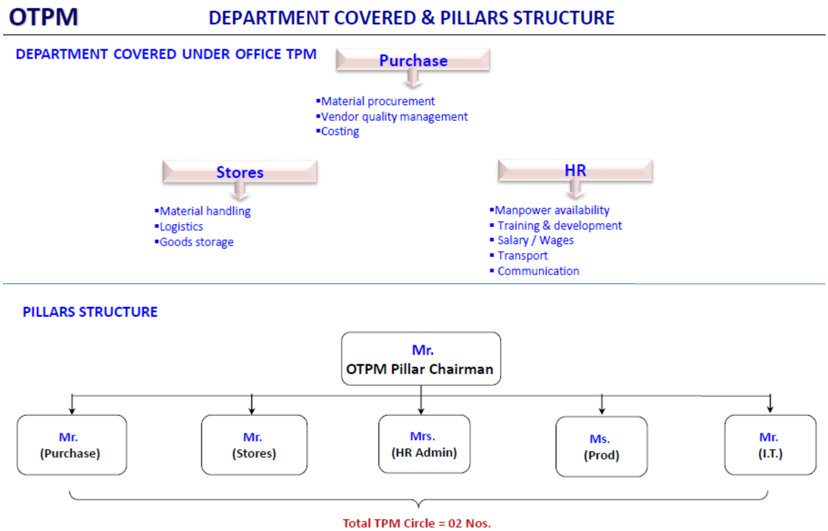

Figure 2-7: Departments and structure of OTPM

Fig. 2-7 shows the service departments purchase, store, HR considered for starting the TPM activities and pillar structure with respective department members involvement.

OTPM LINKAGE BETWEEN KMI / KPI / KAI

Key Management Index	Key Performance Index	Key Activity Index	Purchase	Stores	H R
(KMI)	(KPI)	(KAI)			
A. Increase Production	A1 - Production loss due to non availability of materials	A11-Errorless production and material planning .	✓	✓	
		A12-Alternate source development for capacity enhancement	✓		
		A13-Monitoring timely delivery of vendor material.	✓		
		A14-Timely GRN punching of received material.	✓	✓	
		A15-Material unloading & issuance to the shop floor.		✓	
	A2 - Production loss due to poor quality.	A21–Corrective action and preventive action (CAPA) from vendor.	✓		
		A22- Vendor audit.	✓		
		A23- Vendor up gradation.	✓		
	A3 - Production loss due to manpower unavailability	A31–Recruitment of required (skill wise) manpower.			✓
		A32- Availability of manpower.			✓
	A4- Process time reduction in office area.	A41–Maintenance of communication flow.	✓	✓	✓
		A42- Mass schedule updating .	✓		
		A43-Salary and contractual labour bills.			✓
		A44- Reduce retrieval time of documents and files.	✓	✓	✓
B. Sales.	B1-Inventory finish goods	B11–Define Min-Max level and maintain in days.		✓	
		B12- Implement visual display in BSR for inventory level.		✓	
	B2-Spares sales	B21- Three months forecast for spare requirements.	✓	✓	
C. To Decrease variable Cost	C1-Minimize Inventory RM	C11- Lead time reduction	✓		
		C12-Lot size reduction	✓		
		C13-DOL supply	✓		
		C14- Localization of source & Local Warehousing.	✓	✓	
		C15-Material unloading & issuance to the shop floor.	✓	✓	
		C16- Salvage Non-moving inventory.	✓	✓	
		C17- Send back block stock to vendors.	✓	✓	
	C2-Minimize Cost loss	C21- Monitor self life of material.		✓	
		C22- Perpetual inventory of A and B class materials.		✓	
		C23- Aerial space utilization in stores.		✓	

Figure 2-8: Linkage between various criteria.

Fig. 2-8 shows the linkage between various criteria. The criteria considered are the Key Management Index (KMI), Key Performance Index (KPI), and Key Activity Index (KAI). In KMI, the main objectives considered increase production and sales and cost reduction. KPI identifies the criteria to act upon, and in KAI, activities to perform to achieve the objectives are defined.

OTPM **TARGETS - KPI**

Performance Criteria	Sr. No.	Key Performance Indicator	UOM	Mfg. Side	Office Side	Better	B M FY 2010-11	FY 11-12	FY 12-13	FY 13-14	FY 14-15	FY 15-16	FY 16-17
P	P1	Non availability of material	Hrs.	●		↓	14	10	7	4	2	0	0
	P2	High processing time for documentation.	Min.		●	↓	9	7	5	4	4	4	3
	P3	Production loss due to manpower absenteeism.	Min.	●		↓	378	221	176	110	51	0	0
	P4	Process time for attendance updation.	Hrs.		●	↓	16	16	16	16	2	2	1
	P5	Process time for Employee salary.	Days		●	↓	4	4	4	4	3	3	1
	P6	Process time for contractor labour Bills	Hrs.		●	↓	8	7	6	5	5	4	3
Q	Q1	Vendor Material Rejection	PPM		●	↓	3174	2800	2200	1700	1300	400	<300
	Q2	Improve material handling	Nos.	●		↓	5	4	4	3	2	1	0
C	C1	Communication cost	Rs. (Lacs)		●	↓	4.50	4.50	4.50	4.50	3.50	3.50	3
	C2	Low manpower output	Nos.		●	↓	6	6	5	4	3	3	2
	C3	Inventory (RM+BOP)	Days		●	↓	45	45	45	40	35	30	22
	C4	Inward premium freight	Rs. (Lacs)	●		↓	0.82	0	0	0	0	0	0

Figure 2-9: A setting of a target for KPI

Fig. 2-9 represents the setting of KPI targets in terms of PCQDSM to achieve the KMI. For obtaining the desired results, it requires continuous monitoring.

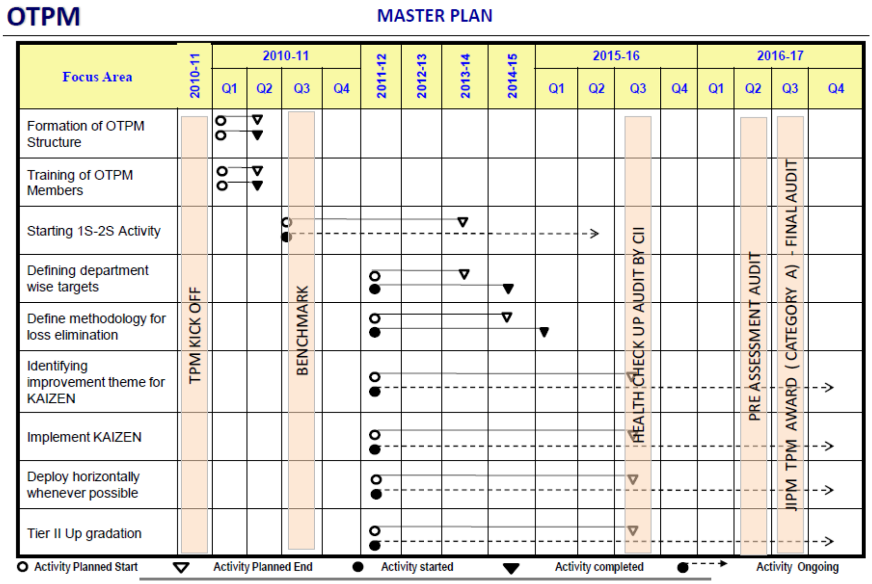

Figure 2-10: Plan to execute OTPM activities

Fig. 2-10 shows the master plan to execute for achieving the results.

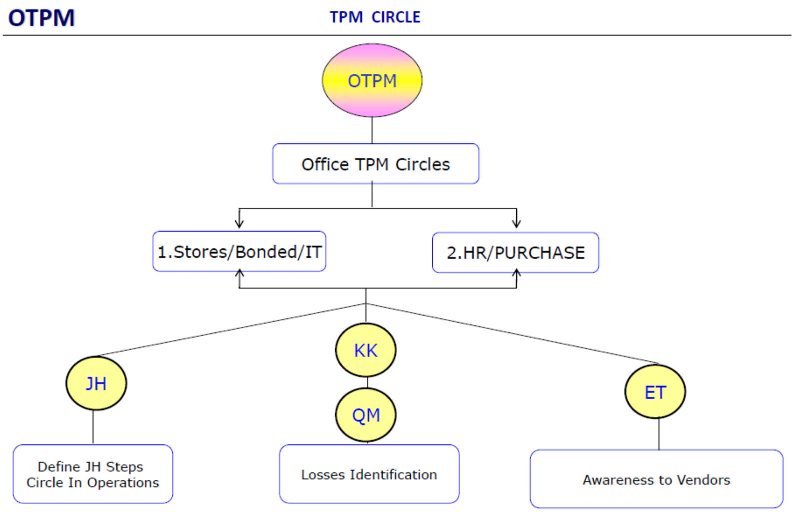

Figure 2-11: TPM circle

Fig. 2-11 shows TPM circle formation for carrying out office TPM activity. It executes various TPM pillars to reduce losses and increase productivity.

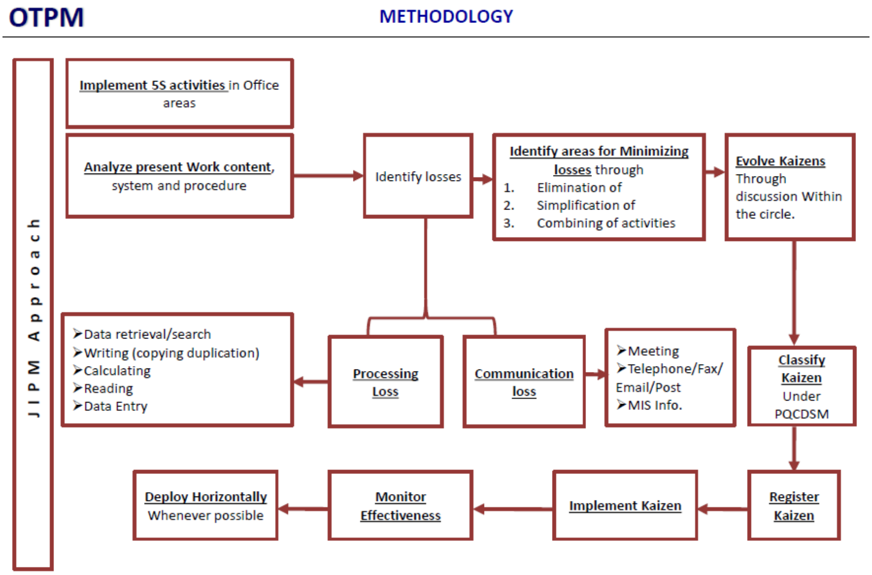

Figure 2-12: Methodology for the execution of OTPM activities

Fig. 2-12 shows the methodology to identify, reduce/eliminate the losses.

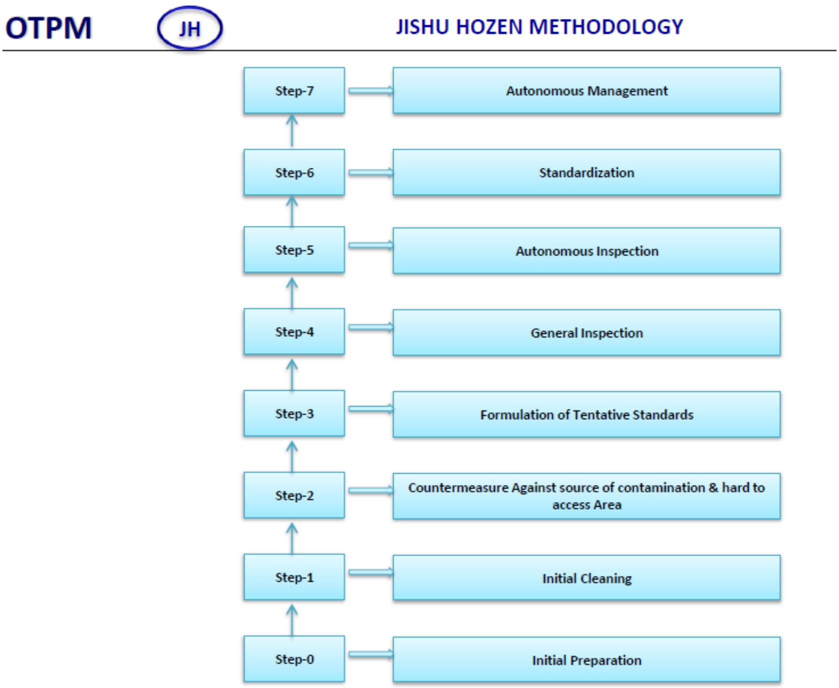

Figure 2-13: JH methodology in OTPM

As shown in Fig. 2-11, various pillars are involved in OTPM. Fig. 2-13 shows the detailed methodology for adopting JH in OTPM. Similarly, it executes methods designed for different pillars.

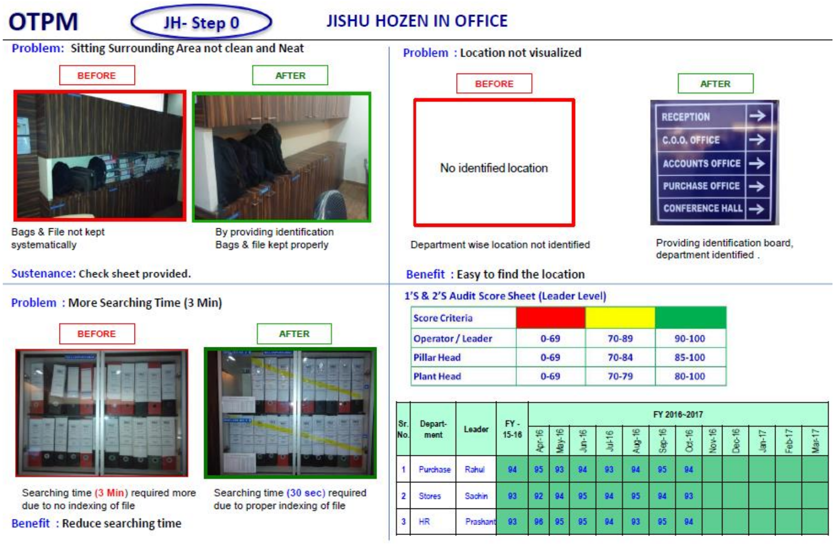

Figure 2-14: Implementation of JH in office

Fig. 2-14 shows the implementation of step zero of JH – practicing 5S. It shows examples of applying 1st and 2nd ‘S of 5S sort and set. It helps to reduce the time loss searching the files, documents, or the location.

Figure 2-15: Implementing 5S

Fig. 2-15 shows implementing 3rd‘S of 5S, i.e., shine. Cleaning the workplace is shown.

OTPM JH- Step 1 **ABNORMALITY MATRIX**

Sr.No.	Description of Abnormalities / Abnormality	Dust	Leak	Spilage	Loose	Missing	Wear	Broken	Chipping	Bend	Holes/GAP	Abnormal Noise	Excessive Heat	Vibration	Discoloration	Abnormal Movement	Total
1	Water Leakage from A.C		5														5
2	Printer Not Working- Paper JAM						6										6
3	Power Supply Socket Borken of Weighing Machine							2									2
4	Light not working					6											6
5	Dust on Ceiling FAN	16															
6	Scrap Yard Room Water Leakage - All door		6														
132	Unwanted Power Sockets																
133	Leackage in Staff Bath room		2														
134	Lan Cable Loose near Lan Switch RACK																

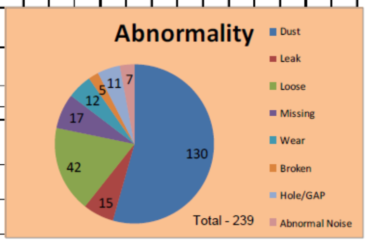

Figure 2-16: Step 1 of JH for OTPM

Fig. 2-16 shows the abnormality matrix for step 1 initial cleaning of JH to be performed for OTPM. It identifies the parameters like dust, leakage, breakages, etc., responsible for the dirty environment in all the departments. Then the description of abnormalities is noted along with the frequency of occurrence.

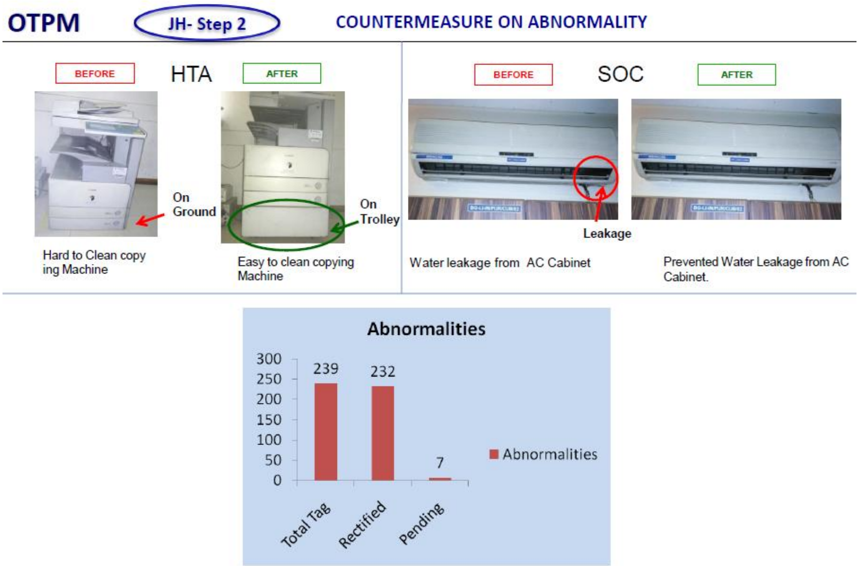

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Figure 2-17: Step 2 of JH in OTPM

Fig. 2-17 shows step 2 for JH, i.e., Countermeasure against the source of contamination & area is hard to access. Before and after data is offered for all the cases. In an example shown in Fig. 2-17, it shifts the Xerox machine lying on the floor onto the table for ease of cleaning.

It conducts and monitors the pillar activities. The results show the improvement in ease of working, increase in productivity, reduction in losses, and overall improvement of the efficiency of the plant.

OTPM pillar implementation examples given in this section are related to the service departments in educational institutes. The activities can be carried out on a similar basis by application of TPM pillars and tools as applied in OTPM to enhance the productivity of the institute,

2.8. SUCCESS STORIES OF TPM

TPM and its pillars are defined in the preceding section. TPM implementation that is competitive increases OEE by reducing losses and rising benefits. This segment goes into a few of the cases. A case study of Indian industries by Singh M. et al. [62] highlighted the benefits of using TPM. It compares TPM and non-TPM implementation industries. Each TPM pillar is rated and analyzed based on the expected output in terms of an increase in OEE. The pillar score analyses the implementation steps accordingly. A comparison of companies with pillar scores of more than 60% and less than 60% is made. The overall performance improvement rate in TPM-implemented companies is noteworthy, with a score of more than 60%. It reflects the need to properly implement TPM in Indian industries, where the emphasis is on machines and quality while safety, education, morale, and motivation are lacking[63].

Table 2-4 contains a list of additional case studies from India and abroad.Table 2-4: TPM Case studies

S N	Reference	Action Taken	Results	Equipment Focused
1	Jamana Auto Industries Ltd, India[64]	TPM implemented – Pereto Charts used, 5s and Kaizen were focused	Reduced Losses & downtime of machines, increased-output/month, availability, performance efficiency, and quality performance	Machines selected - Parabolic and eye-rolling Spring machines.
2	Two-wheeler plant – SIDCUL, Haridwar, India[65]	TPM implemented with 5S, Autonomous Maintenance, Focused improvement, planned maintenance and OEE	Performance rate improved; also, there was an increase in equipment availability, improvement in quality, less rejection, and rework.	Techniques like single minute exchange die (SMED), CMMS, production planning suggested for Machines.
3	Asella Malt Industry, Ethiopia, Africa[66]	It evaluates the effectiveness of TPM implementation. KK and ET were focused.	Improvement in equipment availability, decrease in rework, rejection & increase in the rate of performance.	It analyses the boiler Plant.

4	Steel Company in Jordan[7]	Implementation of TPM – Focused on Quality Pillar and Autonomous maintenance	It shows the improvement in Quality and minimizes wastage of time and material.	Involvement of all dept. from supplier to dispatch to eliminate inter-departmental boundary.
5	Manipal Packing Solutions, India[67]	TPM implemented for checking of OEE of various machines.	Depending on the OEE, it suggests corrective actions for each machine.	Machines monitored – Printing, Punching, Gluer & Lamination.
6	Cotton Spinning Plant[68]	TPM implements in one section and works out all eight pillars.	Improvement in the availability, Performance efficiency, quality rate, improved OEE	It selects the pilot machine in production from the critical section.

Table 2.4 illustrates how TPM implementation yields important performance. However, it also reflects that the focus is on specific resources such as 5S, kaizen, Pareto charts, or specific pillars for one of the PCQDMS variables. The results of a survey conducted in Indian industries show the shortcomings of TPM implementation. It is mostly due to a lack of awareness and apprehension about investment returns. The primary explanation found is that the implementation of TPM is based on a theoretical approach.

2.9. BARRIERS IN IMPLEMENTING TPM

Tan Chiang Ng proposed that a lean strategy can be used to address barriers to TPM implementation [69]. He cited an Achanga et al. case report, stating that finance is one of the four major factors influencing TPM implementation. TPM execution is influenced by managers' risk-taking ability for long payback [70]. Basavaraj et al. reported that management policies influence TPM implementation, but his research has been limited to productivity improvement [71]. Mandal and Saha [72] described management and employee conduct as one of the top behavioral enablers. The management team's contribution is critical. Munir et al. [73] identified management techniques as the most significant obstacle to TPM implementation, followed by financial constraints. Jha and Singh [74] described management decisions as one of the obstacles to TPM implementation in their case study. Andres et al. [50] investigated management evaluation and examined senior management engagement and leadership skills as one of the important criteria influencing TPM. Parks and Hans[75] described the success of TPM based on the following points: Cultural

Change – Resistance to change to implement TPM, Top management support and commitment, Co-ordination between team members, communication, Continous improvement – Kaizen like activities. Similarly, many other references quoted on TPM suggest various ways to promote cultural change, training, change in the reward system, and top management support [28]. Mandal used a fishbone diagram to evaluate the barriers in TPM implementation and categorized it into four groups – cultural, technical, behavioral, and strategic [72].

Attri et al. classifies the barriers to implementing TPM in the Indian industry in the following way: Behavioural, Technical, Human and Cultural, Strategic, and operational[76]. Whereas Ahuja[77] has classified the barriers as :

i) Organization – an inability to change managerial & cultural approach, failure to convince unions, wrong focus on TPM, improper communication from top to bottom, inappropriate judgment of an employee's ability due to insufficient time for evaluation, over expectations.

ii) Cultural – resistance to change traditional approach, lack of consistency, trust, unions, attitude and negative mindset towards the organization, selfish,

iii) Behavioural - resistance from employees to adopt new changes, low skill, and inability to accept change in the workplace, improper teamwork, not ready to work at the new place/machine.

iv) Technological – little effort to improve design, reliability, lack of training and skills, less flexibility, poor energy efficiency.

v) Operational – acceptance of high rejection, lack of implementing standard procedures, absence of planned maintenance, resistance to work extra, shabby workplace,

vi) Financial – additional fund required in the beginning to implement TPM, financial constraints from top management.

vii) Departmental – poor teamwork, reluctance from an operator for maintenance work.

2.10. PROBLEM IDENTIFICATION – TPM IMPLEMENTATION

It describes TPM in the above section with background, definitions, approach, and pillars. The effective use of TPM leads the industry to excellence. Success stories of TPM implementations, as well as barriers of implementation of TPM, are also explained.

It is not an easy task to understand and implement TPM, as if a set of standard procedures which, when implemented, will give the desired output in terms of increased Overall Equipment Efficiency (OEE)[76][78]. TPM is widely used to improve the equipment's effective use and obtain a world-class manufacturing system in terms of Quality and Cost[76]. Successful implementation of the TPM is teamwork in which individuals from every department should work together, and it is employee-focused. Due to the experience and expertise operator knows more about his machine and process. Managers and maintenance teams can judge the tasks to be done or the operation to eliminate. They can try different alternatives to make the equipment and process more efficacious [79].

Nevertheless, it considers the decision of the top management. It is how the managers prove the significance of the task in terms of the cost involved and the expected outcome of it, based on their experience, can fix up the priorities. In most of the case studies, it reflects that the successful implementation of TPM is challenging to implement without the support of top management[3]. Financial constraints are more important as per as the management is concerned. If management is convinced correctly, then it takes away the major hurdle in the TPM implementation. It is needed to present the analytical approach to formulate a quantitative analysis of the TPM process to focus on the most important pillar. Top management can lead discussions as per budgetary provision or can allot extra funds for TPM implementation.

A researcher studied a review of the implementation of TPM in various industries over the world. TPM has helped in improving the OEE. We can observe many success stories of TPM implemented in Malaysia, Africa, Jordan, India, China, Japan, and other countries.[80][81][82][66][7]. However, the success rate of implementation of TPM in Indian industries is very less. To the best of the author’s knowledge, most of the literature discusses the failures due to improper implementations of the TPM. A review of TPM implementation in the Indian Service sector shows a tendency of how people react to implement new things. It shows the approach of top management to curb down the budget for several activities, problem of purchase and replacement of material, visionary approach and management support, are some of the factors bearing on effective implementation of TPM in Indian industries[83].

Ahuja & Khamba, in a significant review of TPM, address implementation in Indian industries[84][82][77]. TPM initiatives in the steel plant highlight how TPM implementation improved the production facilities in terms of four major criteria – Productivity, Quality, Cost & Delivery in Time. In a typical Indian industry, there is a need to implement TPM, and we should develop a holistic approach towards it.

Teamwork, motivation, and continuous improvement are necessary factors for positive results. Indian industries need to have proactive strategic initiatives to lead the organization to world-class standards in today's competitive world. TPM factors are analyzed by exploring the need, characteristics, and challenges of TPM, pointing out the obstacles for effectively implementing TPM in Indian industries[83].

Indian industries are also facing challenges due to the following lacunae: sluggish response to change with the current market scenarios, traditional organizational structure, low quality and productivity, lacking in employee skill, education, motivation and safety, low automation, more wastage, failure to deliver in time, customer complaints, taxes, and infrastructural lacunas.

Failure in implementing TPM is also observed due to barriers, as mentioned above. So, it needs to study TPM pillars concerning PCQDSM, considering 5M’s (Man, Machine, Material, Methods, and Money). It is essential to identify the priority of the TPM pillar analytically, considering such factors. The management is convinced to implement the changes step by step and monitor the returns and see the improvement in OEE to make the industry achieve world-class excellence[64]. The multi-criteria decision-making method makes a pairwise comparison between pillars. One of them is the Analytical Hierarchy Process (AHP).

A lot of improvements have been made through TPM in Indian industries by using AHP. But only the importance of TPM versus Traditional maintenance system (TMS) is analyzed [62]. Other researchers are making similar attempts to justify TQM by using AHP. Proper application of AHP or any other analytical method for the hierarchy of the TPM pillar is missing. It shows that the research going is traditional with a theoretical approach and focusing on very few aspects.

AHP makes it possible to assess the criteria based on the experience[85]. Suppose the ranking of pillars is made in hierarchical order. In that case, it will be easy to focus on the particular task of comparatively higher priority and the forecast done with saving plans. As per the hierarchy of pillars, focus can be on the critical maintenance activities, with optimum use of the resources, which will increase OEE. Simoes et al. [86] reviewed data of the past 30 years, concludes that maintenance needs a practical approach rather than a theoretical one demanding future development and research done in that direction.

2.10.1. ANALYTICAL APPROACH:

TPM is now becoming so popular that most production-oriented industries attempt to embrace TPM in a quest for manufacturing excellence. A study of literature on TPM reveals that most of the reported information qualitatively describes the eight pillars without resorting to utilizing mathematical modeling. Most of the research available gives an account of how a particular industry applied TPM and achieved increased productivity, quality, etc., at a reduced cost. It is almost a monotonous repetition of the eight pillars. There is no attempt to rank the pillars quantitatively to be a helpful guideline for research into Total Productive Maintenance.

The research work carried by the candidate based on the data collected through a survey for pairwise comparison of the pillar uses the AHP method for ranking of TPM pillars. The ranking of the TPM pillars depends on the following points [87]:

(1) Use of Analytical Hierarchy Process (AHP).
(2) Analysis carried out by using a paired comparison of each of the eight pillars with the objectives; Quality, Cost, Delivery on time, and Productivity.
(3) Determine the contribution made by each pillar to the four attributes PCQD, Productivity, Cost, Quality, and Delivery. Finally, each pillar's ranking about the total contribution towards making the industry a World Class Company.

As a part of the research methodology, the paired comparison data has to be collected by the candidate on specially designed questionnaires in consultation with the Management representatives of some companies or other persons responsible for TPM implementation. The Management representatives have overall responsibility for TPM planning and execution. Apart from the Management representative of TPM, the candidate will also be required to consult the various pillar heads of the industry to make the data more authentic. Each of these pillar heads is an experienced senior manager aware of all the pillars and their impact on Quality, Cost, Delivery in Time, Productivity, etc.

Implementation of TPM in industries has proven productivity improvement, reduction in losses, thus increasing efficiency. Indian technical education is facing a lot of challenges, from enrollment to employability. The practical implementation of TPM in the education system will help to improve the efficacy of the education system. The following section describes the background of the technical education system in India.

2.11. HIGHER TECHNICAL EDUCATION SYSTEM IN INDIA

Higher technical education in India has seen many changes since its inception. Professional education currently faces the problem of employability and enrollment. The section describes the development of technical education. In 2002, U.R. Rao (a prominent scientist and former chair of the India Space Research Organization) headed the committee of five-member, established by MHRD for performance review of the AICTE. The committee suggested in their report describing the technology sector is growing irregularly at an untenable level and needs regulation for improving academic standards.

The following are a few of the recommendations from the report [14].

- Many numbers of institutions due to unregulated growth, mainly in the private sector
- Faculty qualification not enough, and not nearly enough doctorates coming through the system
- Weak quality-assurance structures, especially accreditation procedures
- Lack of interaction and cooperation between the classroom and industry.
- In engineering graduates, a high level of unemployment and underemployment.
- The economic growth rate is not matching the graduate growth rate.
- Colleges are not meeting the skilled workforce needs of the industry

Facts and figures show that students are not turning to technical education despite the demand for a trained workforce. There is a need to analyze the engineering education system and enhance the teaching-learning process. Many UG students are not capable of meeting the demand of industries without finishing school or additional courses.

Considering the scenario of the Engineering institutes and the demand from the industry, there is a need to develop a strategic model for engineering education in India. Despite providing excellent infrastructure and faculty, the student enrollment is less. There is a need to measure the missing parameters of the institute.

2.12. PROBLEM IDENTIFICATION – EDUCATION SYSTEM

The author observed that similar flaws were detected in the education system while studying the TPM pillar and minimizing the major and minor losses. We can suggest the pillars for excellence in education as like TPM pillars. Expectations regarding students' skillset from industries and the output from academics have a large gap. It is needed to propose a system to increase industry-institute interaction and merge the gap between the two. TPM leads the industries to world-class excellence based on the measuring parameter OEE.

Similarly, there is a need to analyze the parameters in the education system. Many researchers are working on the different aspects of the system. Some define the grading of students, and some on the grading of staff. Few are working on different teaching-learning approaches. Therefore, implementing TPM or equivalent tools in the educational system to enhance the teaching-learning process to be proposed. It will also help explore many hidden parameters/problems in the educational system similar to 16 losses in industries. Research in academics is based on the evaluation of staff and students or based on different learning approaches, some of them discussed in detail in the literature available. A triangular prism model (TPM) is used to examine online learning communities (OLC) by Jared in the USA[88]. But the explanation of context, time, and transformation process is missing. David et al. have proposed a Synthesis and Design Studio (SDS) model for engineering education over traditional teaching-learning methods [89]. Yechun suggested a workshop on simulation tools for process control education along with case studies[90]. All these researches focus on the academic course-related contents and the way to enhance the teaching-learning scheme.
The Indian education system needs to change to sustain itself in a globalized market. Mahadevi Banad et al. had discussed the challenges faced by the education system[91]. Considering the weakness of the Indian Education system, where the parameters like a rigid curriculum learning process, exam-oriented method, lack of multidisciplinary courses, the role of teacher, student and parents, industry-institute interaction, and many more, there is a need to implement a strategic approach in Indian education system[91]. Many researchers have contributed to analyzing the Teacher's and student's efforts[92]. There are many articles available related to evaluate/grade teachers and students[93]. But the focus on students' quality in terms of the knowledge, skills, and attitude required seems to be missing. Considering the literature related to TPM and education, the TPM concept to be proposed to implement in the education sector will enhance the quality of an educational institute. Further chapters attempt to offer a model for the education system.

2.13. TRANSFERRING CONCEPTS OF EFFICIENCY IN INDUSTRIAL PRODUCTION TO HIGHER EDUCATION

TPM implementation in industries consists of eight pillars. The last pillar is Office TPM (OTPM), applied to service departments which are non-production departments like finance/accounts, store, purchase, etc. The seven TPM pillars and tools are used in OTPM to improve the services rendered, thus helping in reducing unwanted costs or improving the efficiency of the departments. Education institutes are like the service industry. The OTPM pillar, if applied to this sector, will enhance the productivity of educational institutes.

The author proposes different pillars in this sector to address the losses/problems in the education sector to enhance the efficacy of the institute. Industry and Technical institutes are the areas of focus in the current research case. Industry converts raw material into finished product through some manufacturing process. In contrast, technical institutes upgrade the students from 12th grade to UG/PG by teaching-learning process and make them industry-ready. The efficiency of industry is improved by TPM, as discussed in section 2.6. A similar process/tool, if applied to the education system, will enhance the quality of technical education.

We can implement this model in the education system by proposing the Total Productive Education (TPE) model for the education system. The author considers the following points while developing the model:

Table 2-5: Transferring efficiency of the industry to the efficacy of the educational institute.

Industry	**Technical Education Institute**
We can convert raw material to finished products.	We can upgrade students with enhanced knowledge, skills, and attitude.
Manufacturing Process to get the required output	Teaching-learning process to develop the students
Use of - Man, Machine, Material, Method, and Money	Use of – Teachers, Teaching-learning pedology, laboratories, training.
TPM – Pillars, Losses, and Tools Pillars – 8 pillars Losses – 16 losses Tool – Various tools to reduce losses	TPE – Pillars, Losses, and Tools Similar to the 8 pillars of TPM, we can propose new pillars for TPE. Instead of losses in the industry, problems in the education system to be identified. We can apply TPM tools to solve the problems and improve efficacy.
Criteria – Productivity, Quality, Cost, Delivery in Time, Safety, and Moral	(Criteria – Productivity, Quality, Cost, Delivery in Time, Safety, and Moral) The author identifies the factors affecting the above criteria in the education system to propose a pillar of TPE.

Table 2-5 helps propose transferring the concept of efficiency of industrial production to higher technical education. This will help to enhance the productivity of the higher technical education system based on the TPM concept.

2.14. RESEARCH PROBLEM FORMULATION: ITS NEED AND SCOPE

The above section discusses the motivation for the research problem. Fig. 2.6 represents the summary of the research problem formulation. The figure broadly has three areas: A. Literature survey, B. Proposed Research, and C. Expected result.

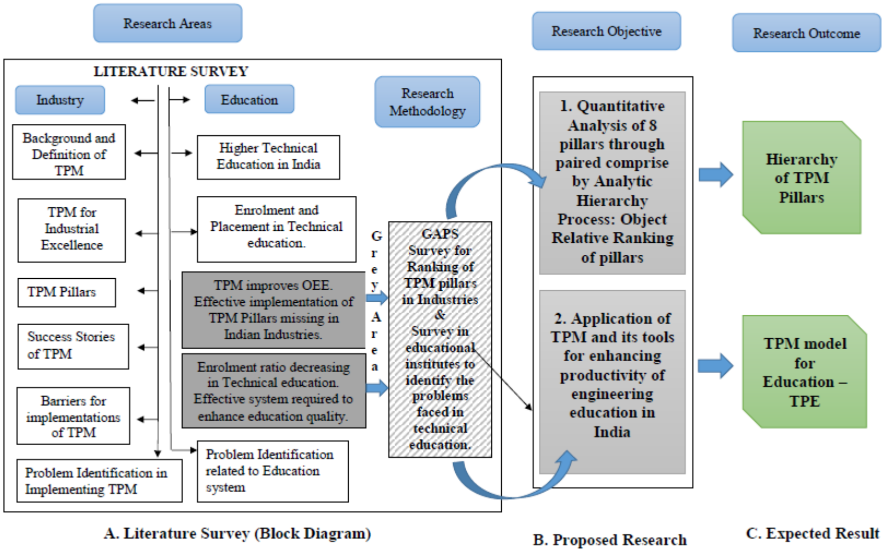

Figure 2-18: Research problem formulation

A. Literature Survey: Survey related to TPM considering Indian industries initiated.

TPM is a powerful tool in industries for increasing OEE and achieving industrial excellence. TPM and its resources are being researched. TPM success stories are also shared. The advantages of TPM in industries for reducing losses and increasing productivity are astounding.

Taking into account the prior concept of introducing such a tool in the education sector to increase the system's efficacy and boost the employability ratio in higher technical education, the author proposes to launch the model. As a result, it addresses the literature survey on higher technical education from admission to employability at the same time. The problem is formulated in order for the education sector to benefit from the TPM tool in the same way as other sectors do. The TPM literature survey was extended in terms of its application in Indian industries. The author observes that TPM implementation is failing in many sectors and identifies obstacles to progress. Based on this, the author develops the research problem.

B. Proposed Research: Based on the literature review, the grey area denotes the difference between the available literature and what is done in industries and institutes. The problem is described by two parameters: 1. the lack of effective implementation of TPM pillars in Indian industries, and 2. the declining enrollment ratio of engineering graduates.

The suggested research approach for working on two problems is to perform a survey. A survey in Indian industries suggested ranking the TPM pillars in hierarchical order for industry-related problems. Conduct surveys in higher technical institutes to classify the issues encountered by stakeholders in the education sector. Based on these two established issues, the study objective is to obtain a quantitative comparison of the eight pillars of TPM, as well as the relative ranking of the pillars. The second goal is to use TPM approach to improve the effectiveness of India's technical education system.

C. Research outcome: The following is the predicted outcome based on the study methodology and proposed outcome: 1. TPM pillar ranking, and 2. Total Productive Education (TPE) model for the educational system.

CHAPTER 3. ANALYTICAL HIERARCHY PROCESS- AHP

The Analytical Hierarchy Process (AHP) is applied to TPM pillar ranking in this chapter. It describes the steps taken in AHP as they relate to the criteria, characteristics, and attributes of the research problem. Identifying the problem with the TPM pillar hierarchy is discussed here by performing a survey and using AHP to determine the ranking of the TPM pillars. It describes the steps taken to rank the pillars in the following sections.

According to the literature in Chapter 2, the TPM approach is a qualitative, quantitative approach that is needed to make it more analytic. This study would offer the best possible solution with an empirical approach to the TPM's current theoretical concept. The report will concentrate on Indian industries that are successfully implementing TPM. The ranking of pillars will provide management with a good understanding of how to execute TPM once it is launched successfully.

Centered on the AHP approach questionnaire, TPM administrators, experts, and consultants participated in a survey to rank the pillars in Indian industries (automotive and assembly sectors). During the pillar rating study, it was clear that the TPM kick-off occurs, but implementation is ineffective and eventually ends. The ranking will provide the necessary emphasis and set the budget's priorities. TPM implementation that is effective contributes to higher OEE.

Thomas L. Saaty developed AHP in the 1970s [4], used for multi-criteria decision-making. The decision-makers arrange the factors in a hierarchical structure and judge the importance of each of these factors. Then, specifying each decision alternative's preference for each factor provides a prioritized ranking order indicating the overall preference for each decision alternatives. An advantage of the AHP over other Multiple Criteria Decision Making (MCDM) methods is that AHP is designed to incorporate tangible and intangible factors, mainly where the subjective judgments of different individuals constitute an essential part of the decision process. When constructing hierarchies, it is necessary to include enough relevant detail to represent the problem as thoroughly as possible.

3.1. ANALYTICAL HIERARCHY PROCESS

Multiple Criteria Decision-Making Model:

The theory, technique, and practice of MCDM problems are abundant in the literature. In general, such a model has the following elements:

- a statement of the problem
- a set of feasible alternatives
- a set of criteria
- estimating scales
- a mapping of feasible alternatives with the estimating scale
- the system of preference of the decision-maker
- the decision rule

Difficulties in obtaining the necessary information cause the basic problems which arise in constructing such models. In many cases, criteria characterizing the alternatives are either incomplete or unknown.
The reasons may be; it does not construct some or all criterion scales, does not obtain estimates for all alternatives in terms of criterion scales, and does not construct the decision rules for getting the required ordering. Thus the formulation of the MCDM models is a complex procedure. It is interesting to note that for any specific multiple criterion problems, no objective model is available. It considers the appropriateness of a model in its practical application to a situation, and it takes many factors into account in a given complex situation.

AHP evolves because of this, enabling decision-makers to represent the interaction of multiple factors in complex and unstructured cases[94].

Development of the AHP Model:
The following assumptions are adhered to while constructing the model:

- The problem should be decomposable into a hierarchical structure - consisting of the overall goal, the criteria, and the decision alternatives.
- Only a few decision-makers can attempt structuring the problem.
- These decision-makers use their knowledge based on their experience, past data, facts, and documents, etc.
- The decision-makers can assign weights to the various criteria and establish rankings of their choices based on the organization's goals, policies, and procedures.

The researcher feels that T.L. Saaty’s Analytical Hierarchy Process is applicable to determine the relative importance of the various pillars.
Depending upon the contribution made by each pillar to Productivity, Cost, Quality, and Delivery in time, as well as the relative weight of each of the four WCM factors PCQD with each other, the final overall weighted score of each pillar can be calculated.

3.2. THE MODEL AND ITS APPLICATION

As previously mentioned, a pairwise comparison approach was used to measure relative values between each of the eight TPM pillars for each other as well as for four criteria: Productivity, Cost, Quality, and Timely Delivery (PCQD). For ranking, a scale of judgments ranging from 1 to 9 (equal to the extreme) is used. Now we will use the process to achieve the main objective of this project, which is to rank all eight pillars based on the four criteria. This section addresses the methodology, assumptions, circumstances, and contributions—implementation of the TPM pillars and its study in the following chapter.

The methodology of AHP consists of the following steps [4]:
Step 1: Statement of problem having attributes and criteria.
Step 2: Represent the problem in the form of a tree.
Step 3: Using a qualitative scale, a pairwise comparison of alternatives.
Step 4: Forming a square matrix of the above comparison.
Step 5: Forming a normalization matrix from eigenvalues and eigenvectors (weights).
Step 6: Check the consistency of the matrix by calculating the Consistency Index, CI. The value of CI should be less than 0.1, as recommended by Saaty.
Step 7: Obtain local & global ratings.
Step 8: Setting priorities or overall goal.

AHP process, specified by T.L. Saaty, applied for finding the hierarchy of the pillars with stepwise methodology and contribution specified herewith:

Step 1: The AHP: is used to calculate relative values between each TPM pillar concerning other pillars and four criteria's PCQD. Therefore, for applying the process, the problem having pillars as Attributes and PCQD as Criteria are defined as shown in Table 3-1.

Table 3-1: Criteria and pillars

	JH	FI	PM	E&T	QM	IFC	OTPM	EHS
Quality								
Cost								
Delivery								
Productivity								

As a requirement of AHP, criteria and attributes are to be defined. The author has selected PCQD as the criteria for the attributes as pillars because of the following reasons:

1. It ranks the pillars as per the hierarchy of execution for implementation.
2. The main reason to implement TPM, and execute the pillar, is to reduce the losses in the process and improve efficiency (OEE).
3. Four parameters PCQD measure the improvement of efficiency. Pairwise comparison between each criterion for the pillar/s can be analyzed relative to quantitative data instead of judgment based on experience.

Step 2: Hierarchy of decisions: The tree below in Fig. 3-1 shows how each pillar contributes to each of the four criteria PCQD.

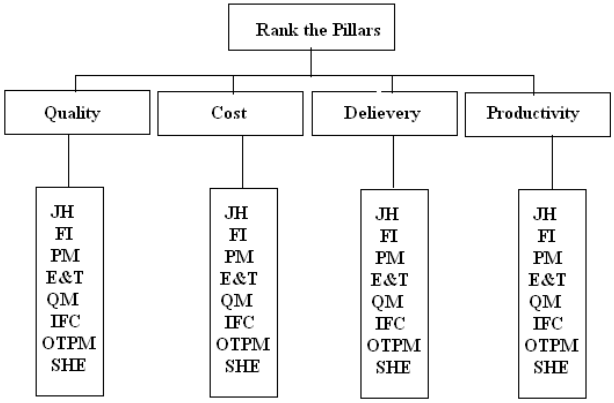

Figure 3-1: Rank of pillars

The above figure gives the representation in tree form for the hierarchy of the pillars as tabulated in Table 3-1.

Step 3: Pairwise Comparison Scale

It uses Nine point Linkert scale for rating the points for the pillars, as shown in Table 3-2 [95].

Table 3-2: Pairwise comparison scale

Importance	Verbal Judgement of Preference	Importance
1	Equal importance	Two activities contribute equally to the objective
2	Weak or slight	
3	Moderate importance	Experience and judgment slightly favor one activity over other
4	Moderate plus	
5	Strong importance	Experience and judgment strongly favor one activity over other
6	Strong Plus	
7	Very strong or demonstrated importance	An activity is favored very strongly over others, and its dominance showed in practice
8	Very, very strong	
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation.

A paired comparison is a methodology in which numerical ratings are assigned to pillars in comparison to another pillar while keeping the PCQD requirements in mind. It uses a scale of judgments ranging from 1 to 9 (equal to the extreme) for rating [96][87]. It bases the judgment on converting verbal to a numerical value which makes algebraic operations possible. Linkert scale, which has odd values, has a midpoint. Besides, a nine-point scale is a better discriminator than a seven or five-point scale. It is preferable to use a wider scale to obtain a more precise judgment value for rating the pillar.

Step 4: Establish Priorities

1. The four criteria in terms of the overall goal
2. The eight pillars in terms of JH
3. The eight pillars in terms of FI
4. The eight pillars in terms of PM
5. The eight pillars in terms of E&T
6. The eight pillars in terms of QM
7. The eight pillars in terms of IFC
8. The eight pillars in terms of OTPM
9. The eight pillars in terms of SHE

It establishes the four criteria PCQD's priorities of the overall goal of the ranking of TPM pillars. Then the priorities of the eight pillars in terms of each pillar are set up.

Step 5: Pairwise Comparison Matrix

This is a critical move. It serves as the foundation for the entire set of outcomes. The aim of the study is to have a quantitative value for expert judgement. It is based on their knowledge that the pillars are rated in relation to each other and using four parameters. It is agreed that a basis of a nine-point Linkert scale is used to translate verbal judgement into a numerical value, and the judgments are tabulated in Table -3-3 [87]. For this, a questionnaire was circulated in order to score the pillars in relation to one another.

Table 3-3: Sample values from the questionnaire

Factor	Factor weighting Score - Quality																	Factor
	More important than								Equal	Less important than								
JH	9	8	7	6	5	4	3	2	***1***	2	3	4	5	6	7	8	9	PM
JH	9	***8***	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM

A novel approach is used, which involves mirroring the scale and thereby providing 18 point choices for greater convenience. It aids in rating the value on the more desirable side, resulting in the reciprocal value on the opposite side. Based on the ratings given, a pairwise comparison matrix is prepared for each criterion. The sample of the pairwise comparison matrix is shown in Tables 3-4. It represents both the reciprocal and the identity matrix.

Table 3-4: Pairwise comparison matrix

	JH	KK	PM	ET	QM	IFC	OTPM	EHS
JH	1.00	2.00	1.00	4.00	1.00	8.00	8.00	4.00
KK	0.50	1.00	4.00	6.00	4.00	8.00	6.00	6.00
PM	1.00	0.25	1.00	4.00	1.00	8.00	6.00	6.00
ET	0.25	0.17	0.25	1.00	0.50	6.00	4.00	4.00
QM	1.00	0.25	1.00	2.00	1.00	8.00	6.00	6.00
IFC	0.13	0.13	0.13	0.17	0.13	1.00	0.50	0.50
OTPM	0.13	0.17	0.17	0.25	0.17	2.00	1.00	4.00
EHS	0.25	0.17	0.17	0.25	0.17	2.00	0.25	1.00

As shown in Table 3-3 from the questioner, the JH is compared with different pillars, a rating of 1.00 is given to JH w.r.t. PM as both are equally contributing. Whereas JH is of more importance than OTPM, so rated as 8.00 (as marked in Table 3-4), reciprocal of JH with respect to other pillars is shown in the first row.

Step 6: Normalization

It is the synthesizing of judgments. It sums the columns in the Normalization process. In the next step of synthesis of judgment, ' divide element of column total,' we get the fraction of unity in each cell. Table 3-5 shows an example for the calculated values of the normalization matrix for various pillars with respect to Quality as criteria.

Table 3-5: Criteria - Quality: Normalization matrix

	JH	KK	PM	ET	QM	IFC	OTPM	SHE
JH	0.261	0.420	0.194	0.336	0.258	0.205	0.199	0.163
KK	0.043	0.070	0.097	0.042	0.129	0.034	0.149	0.163
PM	0.261	0.140	0.194	0.336	0.129	0.205	0.199	0.163
ET	0.065	0.140	0.048	0.084	0.129	0.205	0.199	0.163
QM	0.261	0.140	0.387	0.168	0.258	0.274	0.199	0.163
IFC	0.043	0.070	0.032	0.014	0.032	0.034	0.025	0.082
OTPM	0.033	0.012	0.024	0.010	0.032	0.034	0.025	0.082
SHE	0.033	0.009	0.024	0.010	0.032	0.009	0.006	0.020

The normalization matrix for other criteria is obtained similarly.

Step 7: Consistency check

Saaty[97] proposed that the consistency index should be less than 10% if not the priorities do not make any sense, and the judgments may need revision for various pillars for individual values for PCQD as criteria. A consistency check was conducted after the normalization matrix.

Saaty [97] has proposed a consistency index (CI), which is related to eigenvalue as given by Eq. 1

$$CI = \frac{\lambda_{\max} - n}{n-1} \quad \text{...} \quad (1)$$

Where n = dimension of the matrix, λ_{max} = maximal eigenvalue.
The consistency ratio CR is given by Eq. 2 :

CR =CI/RI ……………………………………………………….………… (2)

RI is the random index, selected from the standard values given, and ‘‘RI is the average CI of 500 randomly filled matrices’’[97].

Step 8: Results
After getting the weighted point values, the pillars are ranked accordingly in hierarchical order.

AHP is the systemic approach for pairwise comparison. The steps are discussed above. The results depend on the matrix formed by taking the values through the questionnaire floated. Based on the judgment of the experts, the quantitative analysis is done by AHP. According to the steps discussed for AHP, the following section shows the formulation for the research problem.

3.3. ASSUMPTIONS IN PAIRED COMPARISON

While awarding point ratings, remember that :

- Suppose there is TPM carried out under the guidance of a Japanese expert qualified at JIPM. In that case, he will not agree to take up the project unless the industry already has 5S culture ensuring environmental cleanliness and safety.
- It will be more rational if the industry happens to be an engineering industry of assembly-type instead of a process plant where dust and contamination of air, water, etc., are dominant.
- The role of the pillar office TPM will not have much effect on quality if there is a certified vendor. However, OTPM will affect Cost, On-time Delivery, and Productivity because of purchasing departments and other office departments' roles in supply chain management.

- Initial flow control addresses new products and equipment. For an ongoing system, its effect is taken very small by the candidate. During the TPM project, if any machine or equipment needs a redesign, reconditioned, or significant overhaul, initial flow control comes into the picture. In the candidate's experience, such occasions are rare. Due to this, the IFC pillar diminishes in importance vis any other pillar during a paired comparison [87].

The study's aim is to determine which pillars are more important than others. Though subject experts may point out hierarchy based on practise, the current work aims to numerically quantify the critical pillars. When everything is measurable, it is easier to manage and control.

CHAPTER 4. RANKING OF TPM PILLARS

As mentioned in Chapter 2, TPM is comprised of eight pillars, with the 5S base, with each focusing on a specific criterion to improve efficiency by reducing various losses. 5S is the foundation of the TPM pillars. The first phase in implementing TPM in stages is 5S. It is essential to understand the priority of pillars to introduce TPM in the industry successfully. Chapter 3 goes through the AHP steps and also the formulation of the problem for TPM pillar ranking. According to the guidelines in Chapter 3, this chapter proposes a ranking of the TPM pillars using AHP. The case under consideration is for industries in the automobile sector. It can be used successfully in a variety of industries..

4.1. ANALYSIS OF TPM PILLARS

Productivity, cost, quality, and on-time delivery are the four pillars of industrial excellence (PCQD). TPM pillars are focused on a number of criteria that seek to reduce eight major and sixteen minor losses in industries. The value of individual pillars will be calculated through an analysis of the pillars in relation to each other in terms of PCQD. It will make it easier for discussion makers to concentrate on a specific pillar and provide funds to complete the challenge.

4.2. DATA FOR RANKING OF THE PILLARS

Expert's opinion in terms of the feedback to questionnaire helps to gather the required data. As pr AHP, the questionnaire is formulated for each criteria PCQD to compare each pillar with respect to each other for the given criteria based on nine-point scale rating. Data collection is through the set of questions in the form of tables circulated to note the response. For eight pillars set of seven tables are required (Annex. – I). The format for the data collection is as per Table 4.1. All the data is then tabulated as Table 4.2, summarizing all the pairwise comparisons.

4.2.1. QUESTIONNAIRE FOR PAIRWISE COMPARISON OF PILLARS

As stated earlier, the survey questionnaire is designed and filled by competent respondents who are knowledgeable about TPM from various Indian industries. TPM consultant is preferred, as they are working with multiple industries. A proforma of the questionnaire, as shown in Table.. 4-1:

Q1. How will you rate the contribution of the following pillars with respect to the JH pillar in terms of Quality?

Table 4-1: Questionnaire for pairwise comparison of various TPM pillars

Pillar	**Rating**	**Justification**	**Remark**
KK			
PM			
ET			
QM			
IFC			
OTPM			
EHS			

Tabulate the data obtained from the nine-point Linkert scale rating questionnaire in the format shown in Table 4-2 for Quality as criteria.

Table 4-2: Data for pairwise comparison of various pillars in terms of quality

Quality									
		1	2	3	4	5	6	7	8
		JH	FI	PM	E&T	QM	ISC	OTT	EHS
1	JH	1	6	1	4	1	6	8	8
2	FI		1	0.5	0.5	0.5	1	6	8
3	PM			1	4	0.5	6	8	8
4	E&T				1	0.5	6	8	8
5	QM					1	8	8	8
6	ISC						1	1	4
7	OTT							1	4
8	EHS								1

The table is further completed considering the matrix, reciprocal of the given values, as shown in Table 4-3.

Table 4-3: Compiling pairwise comparison for Quality

Quality									
		1	2	3	4	5	6	7	8
		JH	FI	PM	E&T	QM	ISC	OTT	EHS
1	JH	1	6	1	4	1	6	8	8
2	FI	0.16667	1	0.5	0.5	0.5	1	6	8
3	PM	1	2	1	4	0.5	6	8	8
4	E&T	0.25	2	0.25	1	0.5	6	8	8
5	QM	1	2	2	2	1	8	8	8
6	ISC	0.16667	1	0.16667	0.16667	0.125	1	1	4
7	OTT	0.125	0.16667	0.125	0.125	0.125	1	1	4
8	EHS	0.125	0.125	0.125	0.125	0.125	0.25	0.25	1

Similarly, the data, along with the reciprocal, is shown for cost, delivery in time. And productivity, in Tables 4-4, 4-5, and 4-6, respectively.

Table 4-4: Data for pairwise comparison of various pillars in terms of cost

Cost									
		1	2	3	4	5	6	7	8
		JH	FI	PM	E&T	QM	ISC	OTT	EHS
1	JH	1	1	1	4	1	4	0.5	4
2	FI	1	1	1	6	1	6	1	6
3	PM	1	1	1	6	1	6	1	6
4	E&T	0.25	0.16667	0.16667	1	0.25	1	0.5	4
5	QM	1	1	1	1	1	4	1	6
6	ISC	0.25	0.16667	0.16667	1	0.25	1	0.5	4
7	OTT	2	1	1	2	1	2	1	8
8	EHS	0.25	0.16667	0.16667	0.25	0.16667	0.25	0.125	1

Table 4-5: Data for pairwise comparison of various pillars in terms of delivery in time

Delivery in Time									
		1	2	3	4	5	6	7	8
		JH	FI	PM	E&T	QM	ISC	OTT	EHS
1	JH	1	0.5	0.5	4	1	6	0.5	6
2	FI	2	1	1	6	4	8	1	8
3	PM	2	1	1	6	1	8	1	8
4	E&T	0.25	0.16667	0.16667	1	2	4	2	4
5	QM	1	0.25	1	0.5	1	8	1	8
6	ISC	0.16667	0.125	0.125	0.25	0.125	1	2	1
7	OTT	2	1	1	0.5	1	0.5	1	8
8	EHS	0.16667	0.125	0.125	0.25	0.125	1	0.125	1

Table 4-6: Data for pairwise comparison of various pillars in terms of productivity

Productivity									
		1	2	3	4	5	6	7	8
		JH	FI	PM	E&T	QM	ISC	OTT	EHS
1	JH	1	2	1	4	1	8	6	4
2	FI	0.5	1	4	6	4	8	6	6
3	PM	1	0.25	1	6	1	8	6	6
4	E&T	0.25	0.16667	0.16667	1	0.5	6	4	4
5	QM	1	0.25	1	2	1	8	6	6
6	ISC	0.125	0.125	0.125	0.16667	0.125	1	0.5	0.5
7	OTT	0.16667	0.16667	0.16667	0.25	0.16667	2	1	4
8	EHS	0.25	0.16667	0.16667	0.25	0.16667	2	0.25	1

4.3. RANKING OF TPM PILLARS:

After the data is composed in matrix form, the pairwise comparison method is adopted further. This section analyses the criteria-wise calculations as per the AHP process.

4.3.1. CRITERIA: QUALITY

For quality AHP approach steps are as follows:

4.3.1.1 Pairwise Comparisons among objectives/alternatives for Quality

Table 4-4 shows the pairwise comparison among objectives/alternatives for quality. For relative term value, the reciprocal marked to complete the table.

Table 4-7: Pairwise comparison among objectives/alternatives for Quality

	JH	KK	PM	ET	QM	IFC	OTPM	EHS
JH	1.00	6.00	1.00	4.00	1.00	6.00	8.00	8.00
KK	0.17	1.00	0.50	0.50	0.50	1.00	6.00	8.00
PM	1.00	2.00	1.00	4.00	0.50	6.00	8.00	8.00
ET	0.25	2.00	0.25	1.00	0.50	6.00	8.00	8.00
QM	1.00	2.00	2.00	2.00	1.00	8.00	8.00	8.00
IFC	0.17	1.00	0.17	0.17	0.13	1.00	1.00	4.00
OTPM	0.13	0.17	0.13	0.13	0.13	1.00	1.00	4.00
EHS	0.13	0.13	0.13	0.13	0.13	0.25	0.25	1.00

4.3.1.2 Normalized Matrix – Quality

Table 4-8 gives a normalized matrix for quality as criteria.

Table 4-8: Normalized matrix – Quality

JH	KK	PM	ET	QM	IFC	OTPM	EHS
0.2609	0.4198	0.1935	0.3357	0.2581	0.2051	0.1988	0.1633
0.0435	0.0700	0.0968	0.0420	0.1290	0.0342	0.1491	0.1633
0.2609	0.1399	0.1935	0.3357	0.1290	0.2051	0.1988	0.1633
0.0652	0.1399	0.0484	0.0839	0.1290	0.2051	0.1988	0.1633
0.2609	0.1399	0.3871	0.1678	0.2581	0.2735	0.1988	0.1633
0.0435	0.0700	0.0323	0.0140	0.0323	0.0342	0.0248	0.0816
0.0326	0.0117	0.0242	0.0105	0.0323	0.0342	0.0248	0.0816
0.0326	0.0087	0.0242	0.0105	0.0323	0.0085	0.0062	0.0204

4.3.1.3 Weightage Point Ratio for Quality

Table 4-9: Weightage point ratio: Quality

Quality		
Pillars	Weights	%
JH	0.2544	25.44
KK	0.0910	9.10
PM	0.2033	20.33
ET	0.1292	12.92
QM	0.2312	23.12
IFC	0.0416	4.16
OTPM	0.0315	3.15
EHS	0.0179	1.79
	1.0000	100.00

Weights	Products	Ratio
0.2544	2.3962592	9.419614
0.0910	0.7891368	8.674987
0.2033	1.9168084	9.429588
0.1292	1.1859414	9.178707
0.2312	2.0604103	8.9131
0.0416	0.3624677	8.717969
0.0315	0.2622089	8.328157
0.0179	0.1498239	8.354735
	CI=	**0.1253**
	CI/RI=	**0.09**

Note: Weightage of JH Pillar is highest followed by QM pillar when we focus on Quality as the Criteria.

4.3.1.4 Analysis for Award of points in Paired Comparison: Quality as Criteria

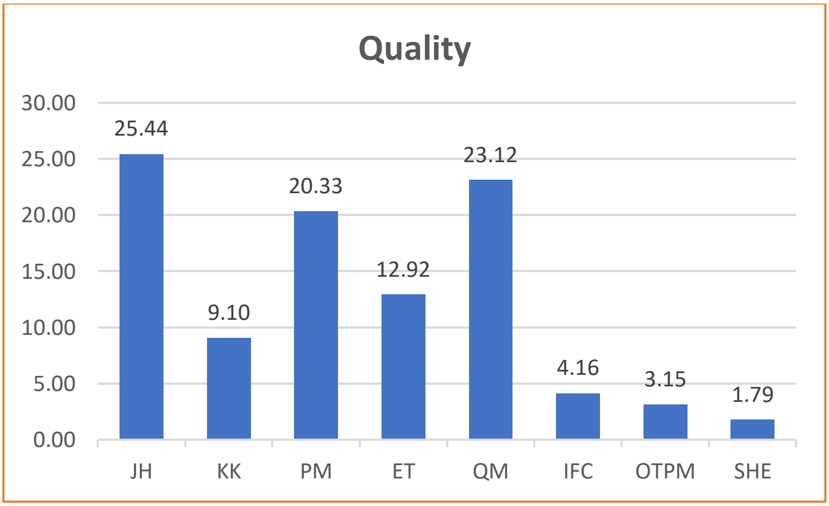

Figure 4-1: Graphical representation of award points in paired comparison: Quality

Referring to data from Table 4-10 or 4-7, rating for pairwise comparison of various pillars in terms of quality is given as per the following discussion:

Row 1: Comparing Various pillars with respect to JH

JH - KK – KK only recognizes that among 16 types of losses, quality and defect, rework loss are major losses, but it does not immediately reduce it. On the other hand, JH contributes the maximum through the implementation of JH steps. For example, step 1 works to bring the machine back to its original condition and remove all major/minor defects of the device. In step 3 of JH, it standardizes activities to maintain primary conditions. In step 5, it works to reduce quality defects with the help of ET through enhancing operational skills and understanding the relation of quality defects and machine operation and mechanism. It also identifies Q components for inspection through the QM matrix and the most crucial machine condition and prevents defects and rework losses. JH, with all these merits, is awarded 6 points in a paired comparison with KK.

JH - PM: JH and PM equally contribute to quality. Through PM, we make perfect quality, while JH improves machine condition by implementing steps 1,2 and 5. But the machine condition is maintained through JH and PM through daily JH activities and PM by time-based maintenance, e.g., predictive maintenance, etc. Thus, both JH and PM being equal points, one awarded to JH against the PM.

JH - ET: If we see four major deciding factors of quality, i.e., man, machine, material, and method, JH addresses machine, but ET equally addresses man and method. ET provides all sorts of formal and informal education and training. Even ET could have been continuously awarded more weightage than JH, but ET is only preaching while JH is practicing. ET is of strategic value, while JH is tactical and direct result-oriented. So, a four-point rating awarded to JH compared with ET.

JH - QM: Though JH is about practicing the standards and maintaining primary conditions, it also improves machine conditions through JH implementation. Still, it will have an almost equal contribution to QM because it is a dedicated pillar for Quality. QM works on defects and reworks losses; rather, it eliminates and prevents losses by establishing a system to follow. It also trains people about aspects of quality maintenance. Overall it is responsible for all four factors, i.e., man, machine, material, and money. In the final analysis, JH and QM can be equally rated.

JH - IFC: IFC will have a negligible contribution to improve or maintain Quality in existing production and existing machine. It will contribute through Failure Mode and Effects Analysis (FMEA) or control plan for a new product on the existing machine or M.P. sheet for any product on the new machine. But in the long run, overall, JH will contribute maximum through its implementation effect. A comparative rating of 6 to JH as compared with IFC is rational.

JH - OTPM: OTPM will contribute to quality by keeping an eye on the Quality of Vendor or vendor quality components or incoming raw material. But in extreme cases, defectives can be controlled at receiving inspection. On the other hand, JH will address machine and man while OTPM will address material only for which industry uses certified quality vendors in the long run. A point rating of eight awarded to JH as compared to OTPM.

JH - EHS: EHS will hardly contribute towards Quality except ensuring a safe working environment, so less hesitation to work or act to prevent defect. In the case of process plants and other chemical plants, EHS has a role to play, but in assembly types of engineering plants, the effect of EHS is cosmetic only. Thus JH can be awarded point eight vs. EHS.

Comparing Various pillars concerning KK

KK - PM: KK only recognizes that the defect & rework is one of the 16 losses and creates awareness about quality loss while PM works for the perfect machine for perfect Quality, through its eight pillar activities, in particular zero failure activity, time-based maintenance & predictive maintenance. So KK will have a weak contribution compared to PM. Thus, KK is awarded a score of 0.5 (reciprocal of 2) as compared to PM.

KK - ET: ET addresses man and method, the two important decisive factors of Quality. It educates and trains the people on various methods and tools for defect elimination and prevention. It enhances the operation and maintenance skills of personnel. It also enhances the analytical expertise of the people. While KK only recognizes defect and rework as one type of loss. ET has slightly more importance than KK. Thus KK is awarded a score of 0.5 as compared to ET.

KK - QM: QM will be slightly more contributor than KK. QM is a dedicated pillar for quality, and particularly one type of loss identified by KK. QM establishes to eradicate and prevent defect and rework loss and continues to reduce quality and cost. Thus a score of 0.5 is awarded to KK.

KK - IFC: KK will have a strong contribution to existing machines & products, but for a new machine and new product, IFC will have its share of contribution to Quality. Thus, a point rating of 1 is awarded to KK since both KK and IFC are equally contributing.

KK - OTPM: Compared to OTPM, KK has strong importance because of creating awareness of quality loss. OTPM will contribute only with new vendors due to working on vendor rejections. In the long run, KK can be awarded six points compared with OTPM when dealing with certified vendors.

KK - EHS: At least KK recognizes defects and reworks as one type of loss, but EHS is not related to defect and rework. So KK has very-very strong importance and awarded a point rating of 8 as compared with EHS.

Comparing various pillars concerning PM

PM - ET: If the PM works on the machine, ET will work on man and methods training. PM will develop a perfect machine for perfect quality. ET will develop personnel through education and training on the QM tool and technique and operation skills. However, the PM has moderate importance at a practical level than ET because an average worker can give outstanding performance on an excellent machine. Thus, PM is moderately rated four as compared to ET.

PM - QM: Amongst four factors of quality - man, machine, materials, and money, PM will contribute to one factor, i.e., machine, whereas QM works on all factors. Thus a weightage of ½ is assigned to PM as compared to QM.

PM - IFC: The contribution of PM is of extreme importance than IFC for all reasons, as stated earlier. Thus, a point rating of six awarded to PM.

PM - OTPM: OTPM works only on vendor rejection. The contribution is very less compared to the effect of PM, which will work on the machine. A rating of eight awarded to PM against OTPM.

PM - EHS: PM works on all the factors related to quality, whereas EHS does not directly impact quality. The contribution of PM will be very-very strong as compared to EHS, gaining a score of eight.

Comparing various pillars concerning ET

ET - QM: ET will contribute through various reasons stated earlier. If we see 4M again, then ET will address man & machine training. Thus it will address two factors out of four, while QM will address four factors out of four, and ET will be awarded slight importance of 0.5 compared to QM.

ET - IFC: IFC will not contribute much for existing machines and products, but ET will contribute more for all reasons stated earlier for ET pillar activities towards Quality. A point rating of six could be awarded to ET as compared to IFC.

ET - OTPM: ET will contribute more than OTPM because it is directly related to 4M factors of quality, whereas OTPM only contributes to vendor development. Thus 8 points are awarded to ET as against OTPM.

ET - EHS: ET will contribute maximum compared to EHS for assembly-type industries. A rating of eight awarded to ET against EHS.

Comparing various pillars concerning QM

QM - IFC: QM will contribute more than IFC. It will be maximum because it is a dedicated pillar only for Quality activity, while IFC will not contribute to Quality for existing machines and products. An award of 8 points is made to QM on criteria of Quality as against IFC.

QM - OTPM: While QM is a dedicated pillar for Quality and addresses man, method, and machine, OTPM addresses material, and its weightage to Quality is less, so maximum contribution will come from QM. As such, a rating of eight is awarded to QM on the criteria of Quality as against OTPM.

QM - EHS: For QM versus EHS, a rating of eight is awarded to QM as it is a dedicated pillar for quality.

Comparing Various pillars concerning IFC

IFC - OTPM: IFC compared to OTPM will contribute through product modification while OTPM will contribute by working on vendor rejection. As both contribute equally, rating one is awarded.

IFC - EHS: IFC can be awarded four points as against EHS.

Comparing Various pillars concerning OTPM

OTPM - EHS: There is less contribution to Quality by both pillars. However, OTPM plays the role of vendor evaluation while EHS focuses on the environment. Thus the rating of four could be graded to OTPM as against EHS.

4.3.2. CRITERIA: COST

For cost as criteria, AHP approach steps are as follows:

4.3.2.1 Pairwise Comparisons among objectives/alternatives for Cost

Table 4-11: Pairwise comparisons among objectives/alternatives for Cost

	JH	KK	PM	ET	QM	IFC	OTPM	EHS
JH	1.00	1.00	1.00	4.00	1.00	4.00	0.50	4.00
KK	1.00	1.00	1.00	6.00	1.00	6.00	1.00	6.00
PM	1.00	1.00	1.00	6.00	1.00	6.00	1.00	6.00
ET	0.25	0.17	0.17	1.00	1.00	1.00	0.50	1.00
QM	1.00	1.00	1.00	1.00	1.00	4.00	1.00	6.00
IFC	0.25	0.17	0.17	1.00	0.25	1.00	0.50	4.00
OTPM	2.00	1.00	1.00	2.00	1.00	2.00	1.00	8.00
EHS	0.25	0.17	0.17	1.00	0.17	0.25	0.13	1.00

4.3.2.2 Normalized matrix – Cost

Table 4-12: Normalization matrix: Cost

JH	KK	PM	ET	QM	IFC	OTPM	EHS
0.1481	0.1818	0.1818	0.1818	0.1558	0.1649	0.0889	0.1111
0.1481	0.1818	0.1818	0.2727	0.1558	0.2474	0.1778	0.1667
0.1481	0.1818	0.1818	0.2727	0.1558	0.2474	0.1778	0.1667
0.0370	0.0303	0.0303	0.0455	0.1558	0.0412	0.0889	0.0278
0.1481	0.1818	0.1818	0.0455	0.1558	0.1649	0.1778	0.1667
0.0370	0.0303	0.0303	0.0455	0.0390	0.0412	0.0889	0.1111
0.2963	0.1818	0.1818	0.0909	0.1558	0.0825	0.1778	0.2222
0.0370	0.0303	0.0303	0.0455	0.0260	0.0103	0.0222	0.0278

4.3.2.3 Weightage Point Ratio for Cost

Table 4-13: Weightage point ratio: Cost

Cost		
Pillars	**Weights**	**%**
JH	0.1518	15.18
KK	0.1915	19.15
PM	0.1915	19.15
ET	0.0571	5.71
QM	0.1528	15.28
IFC	0.0529	5.29
OTPM	0.1736	17.36
EHS	0.0287	2.87
	1.0000	100.00

Weights	Products	Ratio
0.1518	1.3292484	8.756611
0.1915	1.6934515	8.841801
0.1915	1.6934515	8.841801
0.0571	0.4801148	8.407476
0.1528	1.302099	8.52106
0.0529	0.4515255	8.533522
0.1736	1.4625254	8.422502
0.0287	0.2479727	8.648414
	CI=	0.088807
	CI/RI=	0.06

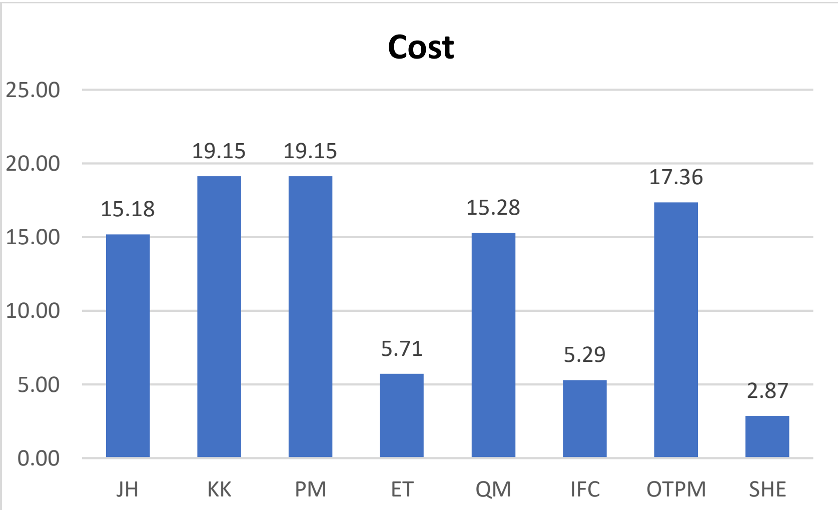

Figure 4-2: Graphical representation of award points in paired comparison: Cost

Note: Weightage of KK & PM Pillar is highest, followed by the OTPM pillar when we focus on Cost as the Criteria.

Referring to data from Table 4-4 or 4-10, rating for pairwise comparison of various pillars in terms of Cost is given as per the following discussion:

Comparing different pillars concerning JH

JH - KK: JH results in the operator attending to his machine and avoiding defects and losses (which incur a cost). KK also aims to reduce losses or costs. Thus point rating of one is awarded to JH in comparison with KK.

JH - PM: JH has the maintenance component embedded in it just as for preventive maintenance. Thus a point rating of one is awarded to JH against the PM.

JH - ET: while JH reduces losses or costs, ET prepares an operator to become proficient in cutting costs. ET has a strategic nature, while JH is shop floor results-oriented, whose contribution is moderate compared to ET. Thus a point rating of four is awarded to JH against ET.

JH - QM: While JH reduces losses or cost, QM focuses on zero defects, and the latter shall also save cost due to defective product and its reworking. So, both play an equal role in cost.

JH - IFC: While comparing JH with IFC, a point rating of four is awarded to the former because the latter does not have much role for ongoing equipment or products except for occasional value analysis effort.

JH - OTPM: JH cuts cost through the operator producing a defect-free product, but OTPM, owing to its contribution in vendor negotiation, enables directly material cost-cutting. Thus a rating of 0.5 is awarded to JH against OTPM.

JH - EHS: JH is more effective because EHS contributes to the operator's confidence and morale through productive guards, which are slightly effective compared with direct JH effort. So, JH is moderately plus, gaining four points as compared to EHS.

Comparing various pillars concerning KK

KK - PM: KK reduced losses and cost while PM results in zero breakdowns (Ideally). So both ought to be ranked equally.

KK - ET: KK reduces losses due to quality loss, speed loss, and unavailability loss, whereas ET is meant for long-term benefits. Thus KK being strongly important, can be awarded a weightage of six against ET.

KK - QM: KK cuts cost due to reduced losses while QM aims at zero defects. Thus both rank equally.

KK - IFC: When comparing KK with IFC, a rating of six is awarded to KK because IFC does not contribute much for ongoing products while KK directly contributes to it.

KK - OTPM: KK and OTPM contribute equally to cost-cutting because OTPM, through its role of streamline purchase and supply chain activity, is as effective as KK. Thus a rating of one is awarded.

KK - EHS: KK has substantial importance in cost-cutting because pillar EHS has an indirect or intangible benefit towards worker morel and Quality of life. Thus a rating of six is awarded to KK.

Comparing various pillars concerning PM

PM - ET: Comparing PM with ET, it is to be noted that the PM has a zero breakdown as the objective, whereas ET aims to increase the operator's behavior and competency. The PM efforts have an immediate impact on cost, while ET has a long-term effect. Thus PM possesses strong importance than ET, with a rating of six.

PM - QM: Comparing PM with QM is like comparing zero breakdowns with zero defects. Both are equally cost-effective and awarded a rating of one.

PM - IFC: PM works on zero breakdowns in the process, while IFC impacts the initial stages. Comparing PM with IFC, a rating of six was awarded to PM.

PM - OTPM: PM and OTPM are equally cost-effective because while PM results in Zero breakdowns, OTPM controls vendor and SCM costs. Thus a rating of one is awarded to PM.

PM - EHS: PM has a direct impact as compared to EHS related to cost. A rating of six to PM as compared to EHS seems ok.

Comparing various pillars concerning ET

ET - QM: ET is compared with QM, both are strategic initiatives, and though QM is slightly more effective in cost-cutting due to its zero-defects philosophy, ET is also useful for operator Moral and Effectiveness. Thus both are equal, a rating of one awarded to ET.

ET - IFC: ET has equal importance with IFC. ET plays a role in training the people and IFC for initial process control; both have long-run effects on cost. So, the rating of one awarded to ET.

ET - OTPM: OTPM helps in cost-cutting through vendors and material costs, while the effect of ET is after training the operators. OTPM has slightly more effective than ET; thus, ET is awarded 0.5 as compared to OTPM.

ET - EHS: It is noted that even though ET is very important, it becomes cost-effective in the long run, with skill development in operators and its tangible benefits to be felt. EHS is equally important as the operating environment, safety, and motivation to operators are concerned. An equal rating awarded.

Comparing various pillars concerning QM

QM - IFC: Comparing QM with IFC, it is to be noted that QM aims at zero defects while IFC claims product cost control through development work and equipment modification. Since the latter is less frequent in ongoing conditions, a rating of four awarded to QM compared with IFC.

QM - OTPM: QM, compared with OTPM, is awarded one point because, while QM aims at zero defect in production, OTPM aims at zero defect in raw material supply.

QM - EHS: QM, related to zero defects, has strong importance than EHS in terms of cost. So, when compared, QM is granted six points.

Comparing various pillars concerning IFC

IFC - OTPM: IFC is awarded 0.5 ratings compared with OTPM because the latter is more cost-effective in terms of vendor cost-cutting for an ongoing process.

IFC - EHS: IFC is awarded a moderate weightage than EHS because IFC has at least some cost control contribution than EHS.

Comparing various pillars concerning OTPM

OTPM - EHS: OTPM is much more effective than EHS in cost-cutting because OTPM controls vendor costs while EHS has no role in cost-cutting.

4.3.3. CRITERIA: DELIVERY IN TIME

For delivery in time as criteria, AHP approach steps are as follows:

4.3.3.1 Pairwise comparisons among objectives/alternatives for Delivery in Time

Table 4-14: Pairwise comparison among objectives/alternatives for Delivery in Time

	JH	KK	PM	ET	QM	IFC	OTPM	EHS
JH	1.00	0.33	0.50	2.00	1.00	4.00	0.50	4.00
KK	3.03	1.00	1.00	3.00	2.00	6.00	1.00	6.00
PM	2.00	1.00	1.00	3.00	1.00	6.00	1.00	6.00
ET	0.50	0.33	0.33	1.00	1.00	2.00	2.00	4.00
QM	1.00	0.50	1.00	1.00	1.00	5.00	1.00	6.00
IFC	0.25	0.17	0.17	0.50	0.20	1.00	2.00	1.00
OTPM	2.00	1.00	1.00	0.50	1.00	0.50	1.00	6.00
EHS	0.25	0.17	0.17	0.25	0.17	1.00	0.17	1.00

4.3.3.2 Normalized matrix - Delivery in Time

Table 4-15: Normalized matrix: Delivery in Time

JH	KK	PM	ET	QM	IFC	OTPM	EHS
0.0997	0.0741	0.0972	0.1778	0.1357	0.1569	0.0577	0.1081
0.3021	0.2245	0.1944	0.2667	0.2715	0.2353	0.1154	0.2162
0.1994	0.2245	0.1944	0.2667	0.1357	0.2353	0.1154	0.1892
0.0498	0.0748	0.0648	0.0889	0.1357	0.0784	0.2308	0.1081
0.0997	0.1122	0.1944	0.0889	0.1357	0.1961	0.1154	0.1622
0.0249	0.0374	0.0324	0.0444	0.0271	0.0392	0.2308	0.0270
0.1994	0.2245	0.1944	0.0444	0.1357	0.0196	0.1154	0.1622
0.0249	0.0281	0.0278	0.0222	0.0226	0.0392	0.0192	0.0270

4.3.3.3 Weightage Point Ratio: Delivery in Time

Table 4-16: Weightage point ratio: Delivery in time

Delivery in Time		
Pillars	Weights	%
JH	0.1144	11.44
KK	0.2229	22.29
PM	0.1931	19.31
ET	0.1050	10.50
QM	0.1396	13.96
IFC	0.0582	5.82
OTPM	0.1384	13.84
EHS	0.0284	2.84
	1.0000	100.00

Weights	Products	Ratio
0.1144	1.0494694	9.169813
0.2229	2.0146035	9.037342
0.1931	1.7570609	9.098676
0.1050	0.9470562	9.019828
0.1396	1.2630037	9.045613
0.0582	0.5416444	9.313858
0.1384	1.1747173	8.489489
0.0284	0.2570568	9.061192
	CI=	0.147068
	CI/RI=	0.10

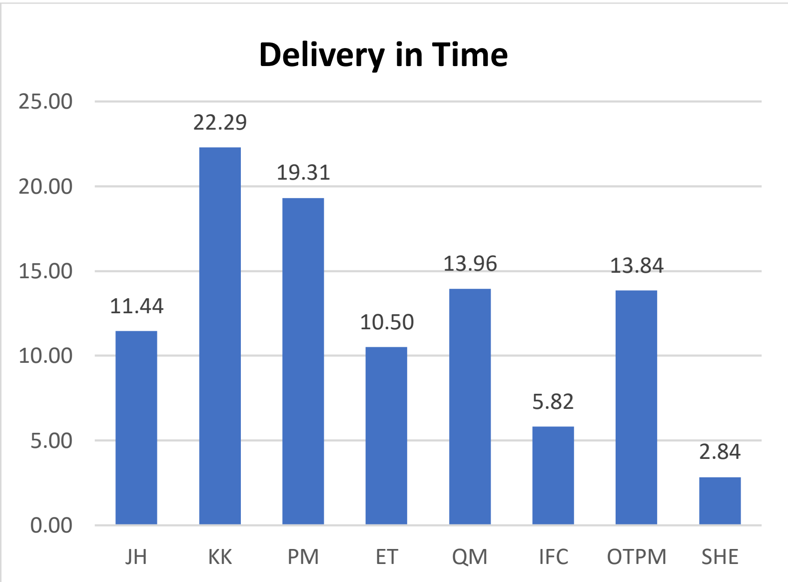

Figure 4-3: Graphical representation of award points in paired comparison: Delivery in time

Note: Weightage of KK Pillar is highest followed by PM pillar when we focus on Delivery in time as the Criteria.

Referring to data from Table 4-5 or 4-13, rating for pairwise comparison of various pillars in terms of Delivery in Time is given as per the following discussion:

Comparing different pillars concerning JH

JH - KK: Comparing JH with KK, JH indicates autonomous maintenance, which is effective for a timely delivery. However, KK is moderately effective because KK results in greater availability of the machine. Thus, a point of the rating of 0.33 awarded to JH as compared with KK.

JH - PM: Comparing JH with PM, PM has the objective of zero breakdowns. Thus, PM has slightly more effective than JH. Therefore, a point rating of 0.5 awarded to JH as compared to PM.

JH – ET: JH is a shop floor activity. ET is strategic; a point rating of two awarded to JH as compared to ET.

JH - QM: While comparing with JH, it should be noted that the objective of QM is to achieve zero defects and improved performance. JH contributes to delivery in time by reducing losses. Thus, JH and QM could awarded equally, and a point rating of one given to JH compared to QM.

JH - IFC: Comparing JH with IFC, it is to be noted that the latter does not contribute much in terms of saving time except providing a vertical start-up. Thus, a point rating of four may be awarded to JH as compared with IFC.

JH - OTPM: Comparing JH with OTPM, which has a highly effective Supply chain Management effect, OTPM is slightly more effective than JH in terms of delivery in time. Thus, a point rating of 0.5 should be awarded to JH as compared to OTPM.

JH - EHS: JH is more effective than EHS. EHS has just the merit that it gives confidence to workers due to providing them safety. A point rating of four awarded to JH.

Comparing various pillars concerning KK

KK - PM: Comparing KK, which improves machine availability, with PM, which aims at zero machine breakdown, the two initiatives could be ranked equally. Thus, a point rating of one awarded to KK as compared to PM

KK - ET: KK can be rated three compared to ET because the latter is an effort to educate and train, whereas KK results in an immediate increase in the availability of the machine and increased OEE.

KK - QM: KK can be rated two concerning QM as it has slightly more importance than QM, which has the objective for zero defectives.

KK - IFC: KK can be strongly rated six, then IFC, because IFC comes in the picture only if a new product and new equipment are considered.

KK - OTPM: KK and OTPM could be equally rated because while KK aims at machine availability, OTPM effectively speeds up the supply chain.

KK - EHS: KK has much more weightage than EHS, particularly in an assembly-type industry where the role of EHS is not much. Thus, a point rating of six awarded to KK as compared to EHS.

Comparing Various pillars concerning PM

PM - ET: PM, which aims at zero breakdowns, can be rated three as compared to ET.

PM - QM: Both PM and QM can be rated equal because PM focuses on zero breakdown QM focuses on zero defects.

PM - IFC: Comparing PM with IFC point rating of six awarded because IFC has no role to play in old machines producing the same product.

PM - OTPM: PM with zero breakdowns and OTPM with supply chain effectiveness is ranked equally for a timely delivery.

PM - EHS: PM being more effective than EHS could be awarded seven points.

Comparing Various pillars concerning ET

ET - QM: ET and QM can be equally rated as operators' training to help reduce the rejection of the components.

ET - OTPM: OTPM has slightly more importance than ET because OTPM, due to supply chain management, helps in timely delivery. Thus, the point rating of 0.5 awarded to ET compared to OTPM.

Comparing various pillars concerning QM

QM - IFC: QM zero-defect initiative possesses little importance than IFC, which only deals with a new setup. So, the point rating of two awarded to QM.

QM - OTPM: QM is equally effective as OTPM because the former focuses on zero defectives, while the latter focuses on Supply Chain Management.

QM - EHS: QM zero-defect initiative has strong importance, as compared to EHS. So the rating of six is awarded to QM.

Comparing Various pillars concerning IFC

IFC - OTPM: OTPM is more effective due to supply chain management for timely delivery than IFC.

IFC - EHS: Comparing IFC with EHS, both contribute negligibly and should be rated equally.

Comparing various pillars concerning OTPM

OTPM - EHS: OTPM is strongly influential due to supply chain management for timely delivery compared to EHS. So point rating of six awarded to OTPM.

4.3.4. CRITERIA: PRODUCTIVITY

4.3.4.1 Pairwise comparisons among objectives/alternatives for Productivity

Table 4-17: Pairwise comparison among objectives/alternatives for Productivity

	JH	KK	PM	ET	QM	IFC	OTPM	EHS
JH	1.00	2.00	1.00	4.00	1.00	8.00	6.00	4.00
KK	0.50	1.00	4.00	6.00	4.00	8.00	6.00	6.00
PM	1.00	0.25	1.00	4.00	1.00	8.00	6.00	6.00
ET	0.25	0.17	0.25	1.00	0.50	6.00	4.00	4.00
QM	1.00	0.25	1.00	2.00	1.00	8.00	6.00	6.00
IFC	0.13	0.13	0.13	0.17	0.13	1.00	0.50	0.50
OTPM	0.17	0.17	0.17	0.25	0.17	2.00	1.00	4.00
EHS	0.25	0.17	0.17	0.25	0.17	2.00	0.25	1.00

4.3.4.2 Normalized matrix – Productivity

Table 4-18: Normalized matrix: Productivity

JH	KK	PM	ET	QM	IFC	OTPM	EHS
0.2330	0.4848	0.1297	0.2264	0.1257	0.1860	0.2017	0.1270
0.1165	0.2424	0.5189	0.3396	0.5026	0.1860	0.2017	0.1905
0.2330	0.0606	0.1297	0.2264	0.1257	0.1860	0.2017	0.1905
0.0583	0.0404	0.0324	0.0566	0.0628	0.1395	0.1345	0.1270
0.2330	0.0606	0.1297	0.1132	0.1257	0.1860	0.2017	0.1905
0.0291	0.0303	0.0162	0.0094	0.0157	0.0233	0.0168	0.0159
0.0388	0.0404	0.0216	0.0142	0.0209	0.0465	0.0336	0.1270
0.0583	0.0404	0.0216	0.0142	0.0209	0.0465	0.0084	0.0317

4.3.4.3 Weighted Point Ratio: Productivity

Table 4-19: Weightage point ratio: Productivity

Productivity		
Pillars	**Weights**	**%**
JH	0.2143	21.43
KK	0.2873	28.73
PM	0.1692	16.92
ET	0.0814	8.14
QM	0.1551	15.51
IFC	0.0196	1.96
OTPM	0.0429	4.29
EHS	0.0303	3.03
	1.0000	100.00

Weights	Products	Ratio
0.2143	1.973904448	9.2111078
0.2873	2.775612192	9.6614787
0.1692	1.531661226	9.0522481
0.0814	0.712807095	8.7529098
0.1551	1.368788053	8.8279655
0.0196	0.172960993	8.8289448
0.0429	0.361078091	8.4200958
0.0303	0.256011755	8.4620634
	CI=	0.1288717
	CI/RI=	0.09

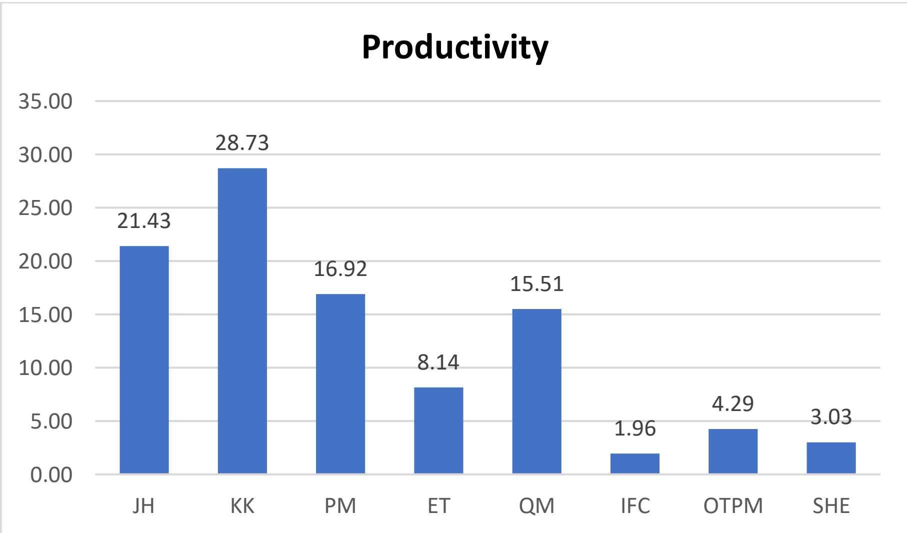

Figure 4-4: Graphical representation of award points in paired comparison: Productivity

Note: Weightage of KK Pillar is highest when we focus on Productivity as the Criteria.

Referring to data from Table 4-5 or 4-16, rating for pairwise comparison of various pillars in terms of Productivity is given as per the following discussion:

Comparing different pillars concerning JH

JH - KK: JH will reduce minor breakdown. It will make the machine a better place, make it safer, and bring it back to its original condition. It is equally vital to aim reduction in losses by KK. Though KK will reduce major losses, as setup, adjustment tool change loss, speed losses such as sustaining all kaizens, the base will be provided by good execution of JH, possessing slightly more importance. Thus, two points awarded to JH compared to KK.

JH - PM: JH is equally important as PM because PM will reduce breakdown to zero and standardize the activities to maintain it to zero. These activities will be periodically executed by PM and partially by JH. But in day-to-day operations, if JH activity is not executed religiously and properly, it will be difficult to maintain the objective of reducing breakdown loss. Thus, one point awarded to JH compared to PM.

JH - ET: ET will train people about JH and its execution, but it will be more important about how JH is executed practically and how it is practiced daily. ET will contribute towards awareness about losses & training of JH, but it is the execution of JH steps and its regular practice, which will contribute more. Thus, four points are awarded to JH as compared with ET.

JH - QM: QM will reduce defects to zero and train people in problem-solving methods, but again the execution of steps of JH, in particular steps 1,3,4 & 5, will make the machine perfect of yielding perfect quality. Thus, putting together the standardization of QM & JH will maintain the machine to produce zero defects. Therefore, both are equally graded.

JH - IFC: IFC is actually for new machines and new products, which means its effect is realized in new machines and products. For existing machines, it is not that effective, so JH has the most contribution. Thus, eight points awarded to JH as compared to IFC.

JH - OTPM: Though maximum contribution will be of JH, OTPM will contribute towards reducing losses arising due to supply chain and other non-value-added activities of supporting processes of supporting departments. Thus, six points are awarded to JH as compared to OTPM.

JH - EHS: Though JH has more contribution, but the human factor cannot be ignored in the productivity of the machine or machine process. If the processing condition of surroundings is not safe for a human to work, it will affect productivity. Similarly, the working conditions should not be unhealthy or unhygienic or should not hurt human beings; that's why the contribution of EHS cannot be ignored. Anything JH will improve it in steps 0-3, but its awareness and importance will be enhanced through EHS. Thus, four points awarded to JH as compared to EHS.

Comparing various pillars concerning KK

KK - PM: KK focuses on reducing losses, defects, and rework, PM on zero breakdowns. The contribution of KK will be moderate than PM. Thus KK awarded four points compared to PM.

KK - ET: KK will have maximum contribution though ET cannot be ignored because the awareness about losses is brought through training only. Training itself will not be enough if it is not utilized properly to reduce the losses. Thus, six points are awarded to KK as compared to ET.

KK - QM: QM will contribute maximum to reduce defects and rework loss. KK reduces the other 14 losses, so it contributes more, but it cannot be most because QM reduces Quality defects, and defects typically loss ranks high in the total loss tree. Thus, four points awarded to KK as compared to QM.

KK - IFC: KK will have a very strong contribution because if the machine is old, while IFC does not have any scope. Thus, eight points awarded to KK as compared with IFC.

KK - OTPM: KK will have a very strong contribution because it will reduce production losses, but OTPM will reduce lean loss and other losses related to the supply chain. All non-value-added activities of supporting departments function. Thus, a six-point rating awarded to KK compared to OTPM.

KK - EHS: KK will have a very strong contribution compared to EHS as it deals with the actual production-related activities. EHS considers a safe and hygienic work environment. Thus, a moderate rating of six points awarded to KK as compared to EHS.

Comparing various pillars concerning PM

PM - ET: Though PM will have the most contribution by reducing major loss and Breakdown loss, ET's contribution cannot be ignored. ET pillar, which trains first and reinforces as and when required to help in reducing losses and executes various productivity improvement tools and techniques. Thus, six points awarded to PM as compared to ET.

PM - QM: PM and QM contribute by reducing respective losses of Breakdown and Quality defects. Thus, a one-point rating given.

PM - IFC: PM will be the most contributors for existing machines because IFC does not reduce any loss or enhance productivity but for a new machine. PM will contribute more because most of the MP sheets will be ranked by the PM pillar, and the PM pillar contributes more toward IFC activity. Thus, eight points awarded to PM as compared to IFC.

PM - OTPM: PM has maximum contribution because it reduces major loss, i.e., breakdown loss, and establishes a system to maintain it for zero level skill. OTPM cannot be ignored as it contributes to reducing supply chain losses and enhancing the efficiency of supporting departments. Thus, six points awarded to PM as compared to OTPM.

PM - EHS: PM is a maintenance contributor, while safety during operation gives confidence to the worker. Thus, six points awarded to PM as compared with EHS.

Comparing various pillars concerning ET

ET - QM: ET contributes less compared to QM because ET trains people to enhance productivity. Only training is not helpful until it is utilized and demonstrated in QM and other pillars. Thus, 0.5 points awarded to ET as compared with QM.

ET - IFC: ET contributes maximum over IFC because, since the beginning of TPM, ET trains all employees in their respective activities to reduce losses. Thus 6 points are awarded to ET as compared to IFC.

ET - OTPM: ET & OTPM are unequal contributors because, on one end, ET imparts training for zero losses while on other ends, OTPM works to reduce non-value-added activities and to make efficient management information system better supporting process and reducing supply chain losses. Thus, four points awarded to ET as compared with OTPM.

ET - EHS: ET trains people while EHS takes care of a safer, cleaner, and healthier workplace to enhance productivity. The direct effect of training is more as compare to EHS. Thus, four points awarded to ET as compared to EHS.

Comparing Various pillars concerning QM

QM - IFC: QM reduces losses & rework, which increases productivity. A point rating of eight awarded to QM compared to EHS.

QM - OTPM: QM reduces defect and reworks loss. Thus, six points awarded to QM as compared to OTPM.

QM - EHS: PM reduces reworking losses. EHS helps in operator safety. Thus, six points awarded to QM compared to EHS.

Comparing various pillars concerning ISC

IFC - OTPM: IFC is less contributor than OTPM because IFC cannot help in increasing the production of the existing machine. OTPM will reduce losses with KK and contribute towards production. Thus, 0.5 points awarded to IFC as compared with OTPM.

IFC - EHS: Again, IFC will not contribute to productivity as EHS will contribute due to the effective reduction of accidents and a happier place to work. Thus, 0.5 points awarded to IFC as compared with EHS.

Comparing various pillars concerning OTPM

OTPM - EHS: OTPM and EHS will be unequal contributors as OTPM will contribute towards lean, supply chain, timely delivery of materials, and resources. EHS will contribute towards zero accidents and make the operator less hesitant towards the machine or process. Thus, four points awarded to OTPM as compared with EHS.

Summary of Comparison:

As tabulated in the pairwise comparison results in the above section, the summary of weightage - QCPD and pillars are given in Table 4-19 and represented graphically in Fig. 4-5.

Table 4-20: Pairwise comparison summary among QCPD and TPM pillars

	% Weightage			
Pillar	**Quality**	**Cost**	**Delivery in Time**	**Productivity**
JH	25.44	15.18	11.44	21.43
KK	9.10	19.15	22.29	28.73
PM	20.33	19.15	19.31	16.92
ET	12.92	5.71	10.50	8.14
QM	23.12	15.28	13.96	15.51
IFC	4.16	5.29	5.82	1.96
OTPM	3.15	17.36	13.84	4.29
EHS	1.79	2.87	2.84	3.03

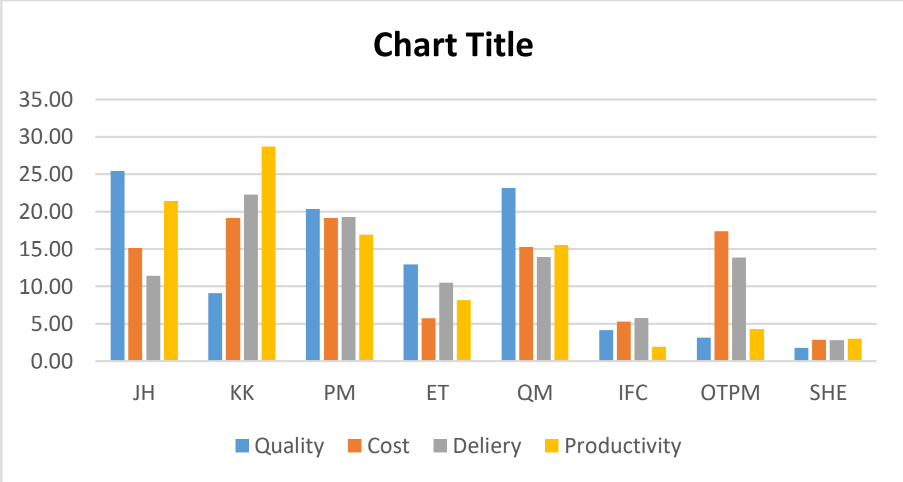

Figure 4-5: Representation of criteria's for various pillars

4.3.5. PAIRWISE COMPARISONS AMONG CRITERIA'S

After comparing eight pillars concerning each other, this section represents the pairwise comparison of criteria, a next step in the AHP process.

Table 4-21: Pairwise comparison among criteria's – QCPD

	Quality	Cost	Delivery	Productivity
Quality	1.00	4.00	2.00	1.00
Cost	0.25	1.00	0.50	0.17
Delivery	0.50	2.00	1.00	0.50
Productivity	1.00	6.0	2.00	1.00

Table 4-22: Normalization matrix: QCPD

Normalized matrix			
0.3636	0.3080	0.3636	0.3750
0.0909	0.0770	0.0909	0.0626
0.1818	0.1540	0.1818	0.1875
0.3636	0.4610	0.3636	0.3750

Table 4-23: Weightage point ratio: QCPD

Criteria		
	Weights	**%**
Quality	0.3526	35.26
Cost	0.0804	8.04
Delivery	0.1763	17.63
Productivity	0.3908	39.08
	1.0000	100.00

Weights	**Products**	**Ratio**
0.3526	1.41735	4.02027
0.0804	0.3219	4.00584
0.1763	0.70867	4.02027
0.3908	1.5771	4.03539
	CI=	0.00681
	CI/RI=	0.01

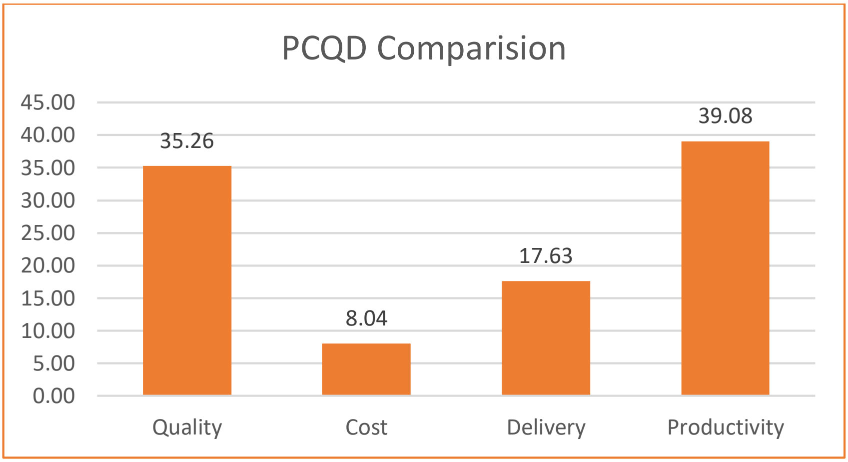

Figure 4-6: QCPD comparison

Note: Comparison of Criteria's shows that the Preferences are given to Productivity & Quality, followed by Delivery in time. The cost has the least weightage.

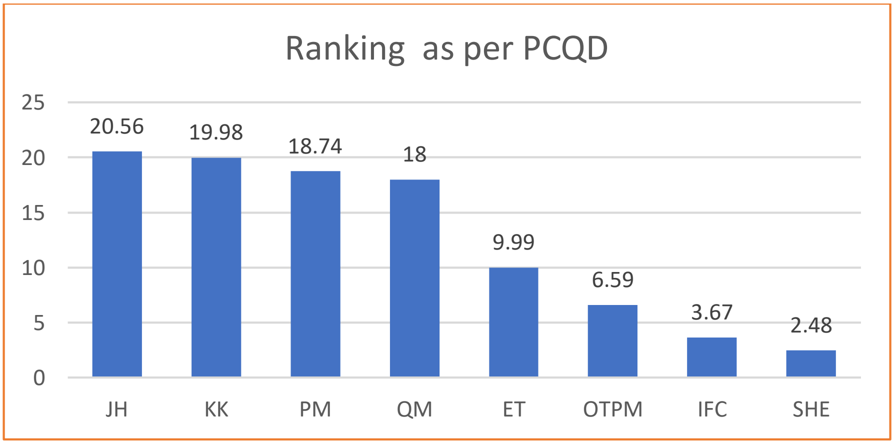

Figure 4-7: Ranking of TPM pillars as per QCPD

4.4. HIERARCHY OF TPM PILLARS

Fig. 4-7 shows the result of the ranking of pillars by AHP. Based on it, Fig. 4-8 shows the hierarchy tree. Thus the ranking of the TPM pillar is suggested with the highest priority to pillar JH followed by KK.

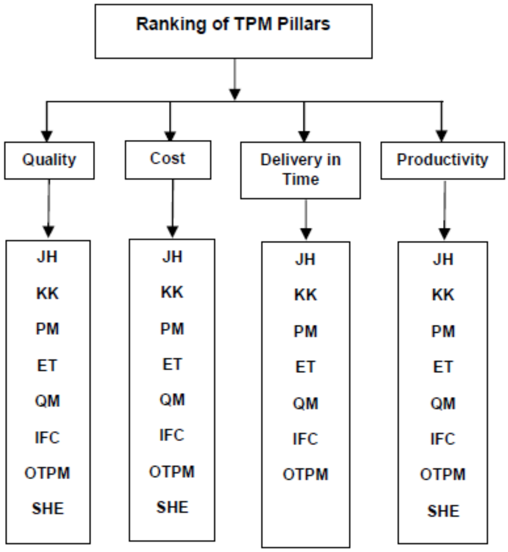

Figure 4-8: Ranking of TPM pillars

4.5. CONSTRAINTS

To bring to notice that the hierarchy achieved applies to a particular type of industry set and not be considered as universal. For example:

(1) For the chemical industry, pillar Safety, Health, and Environment are far more important than the engineering industry.

(2) For service-type organizations, pillar Office TPM is more vital, though it is also needed to speed up supply chains in production-type organizations.

(3) Sixteen losses are listed by the Japanese Institute of Plant Maintenance. Focused Improvement as a pillar dedicates to minimizing losses calls for great creativity to eliminate all kinds of losses.

(4) Quality Maintenance, which focuses on Zero defects, depends much on the attitude of Top Managements towards Quality.

CHAPTER 5. AHP IN EDUCATION

In Chapter 4, AHP applied for the ranking of the TPM pillar. This chapter explains how AHP can be used in the education field. The identified criteria and sub-criteria will be used to establish the AHP model for education and the TPM pillars for the education sector.

5.1. TPM FOR EDUCATION SECTOR

TPM has achieved excellent results in industries by rising productivity by enhanced OEE. As specified in section 2.10 of Chapter 2, the aim is to use TPM to improve the efficiency of higher technical education institutes, which will be achieved by identifying problems using AHP in this chapter. The AHP has numerous applications in several industries. Though it was not well-known for ranking the pillars, the preceding section indicates it. AHP is used in many ways in the education field, taking into account various criteria and sub-criteria. AHP recognizes technical education's primary goal. Many TPM approaches can be used to solve/reduce/eliminate problems, and the proposed TPE model can help to increase the educational system's effectiveness.

5.2. AHP IN EDUCATION

Azila Anis gives an overall review of the application of AHP in higher education institutes[98]. The author has summarized the judgment of 33 papers according to the country of origin, publication year, integrated techniques applied along with AHP, and also the Higher Learning Institutes (HLI) areas wherein the AHP was involved, as summarized in Table 5-1:

Table 5-1: Areas of AHP application in HLIs

No.	Areas of AHP application in HLIs	Count	No.	Areas of AHP application in HLIs	Count
1	University library acquisitions	1	8	Faculty evaluation	6
2	Marketing strategies	1	9	Measuring performance	5
3	Measuring quality education of HLIs	6	10	Selection of university majors	3
4	Research award program	1	11	Resource allocation	1
5	Strategic planning	4	12	Total quality management	1
6	University procurement and bidding	1	13	University selection	2
7	University ranking	1		TOTAL:	33

The literature on the application of AHP in the education sector focus above areas, moreover the literature reflects two stakeholders students and faculties in most of the studies. The analysis of the problems is done mainly by considering the criteria related to them as tabulated in Table 5-2.

Table 5-2: Criteria considered for AHP in the Education Sector

Sr No	**Reference**	**Application area of MCDM/AHP**	**Criteria considered**
1.	A decision support framework for performance evaluation of Indian technical institutions by Manik Das et al. [99]	Access the performance of the Indian Institute of Technology (IIT)	1. Faculty strength 2. Student intake 3. Number of Ph.D. awarded 4. Number of patents applied for (Patent) 5. The campus area in acres 6. Tuition fee per semester (TF) in rupees.
2.	A Study on Evaluation and Comparison of Universities based on Multi Criterion Approach Using Analytical Hierarchy Process[100]	PhD thesis proposing a model to be developed based on local stake holder's Parameters and localized views.	1. Students - University Related, Faculty related, Convenience Related 2. Faculty - Job Security, Job progression and Recognition Related 3. Administrators 4. (Directors /Principals /HODs) - Quality of Education, Research Output, Size & Infrastructure, Quality of Faculty 5. Industries - Employability of Students, Collaborative Research
3.	Analytical Hierarchy Process Model for The evaluation of college experimental teaching quality.[101]	Explains the evaluation indicators and their weights of experimental teaching quality developed according to the AHP method.	1. Teaching attitude 2. Teaching contents 3. Teaching methods 4. Teaching results

4	An Investigation about the Characteristics of an Engineering College Teacher in the Current Scenario[102]	A survey-based teacher's opinions regarding the essential quality characteristics of a good engineering college teacher are analyzed.	1. Knowledge (Application areas) 2. Knowledge (Theory, fundamentals) 3. Research orientation 4. Information providing 5. Communication skills 6. Equip students for exams 7. Usage of innovative learning techniques 8. Facilitate learning 9. Keep in pace with technology trends 10. Management ability 11. Role model 12. Social responsibility 13. Accountability 14. Sincerity 15. Helping students
5	Analytical Hierarchy Process approach – An application of engineering education[103]	Applied for selecting the students from college for All round excellence award	1. Attendance 2. Academics 3. Co-curricular activities 4. Extracurricular activities 5. Cultural activities 6. General behavior 7. Departmental activities
6	Decision Support System for Ranking of Students in Learning Management System (LMS) Activities using AHP Method[104]	Discusses on evaluation of students learning process in LMS by taking input from teachers.	1. Assignments 2. Daily tests 3. Quizzes 4. Practicals
7	Determining e-learning success factor in higher education based on user perspective using Fuzzy AHP[105]	Study to analyze the critical factors as reported by staff and students perspective for the success of e-learning.	1. University Involvement 2. Quality of Infrastructure and Systems 3. Quality of Design and Courses 4. Student’s Characteristics 5. Lecture’s Characteristics

8	Determining Students Expectation in Present Education System Using Fuzzy Analytic Hierarchy Process[106]	It investigates the key factors of student expectations, considering students belonging to technical institutes.	1. Infrastructure 2. Faculty Standard 3. Accessibility from city 4. Hotel and food 5. Discipline 6. Bus facility 7. Placement carrier 8. Innovative ideas 9. Fee structure of the institution.
9	Identifying educational services quality using quality function deployment model (QFD) and analytic hierarchy process (AHP)[107]	Identify student demand from the education field and analyze it by classifying it into five dimensions: the professor's features, classroom content, teaching, class structure, and educational facilities.	1. The intimate character of professors 2. Provide articles and speeches 3. Competence in teaching 4. Employment standards 5. Competence in IT 6. Feedback for students 7. Preparing leaflets 8. Consultation hours 9. offered courses to teachers with high academic levels. 10. Long term assignments for students 11. Encourage class discussion 12. Technical knowledge 13. Case study 14. Providing updated content 15. Planning courses by experts 16. Ready for speech 17. Computer sessions 18. Industrial visits 19. Invited speakers from industry 20. Create employed Student 21. Association 22. Cooperation with industry in joint projects 23. Classes with prepared size and ventilation

			24. Equipping computer Site 25. Provide funding for the facility 26. The friendly and respectful behavior of the staffs 27. Create a two-way criticism System 28. Hire professionals to handle criticism System
10	Implementation of the Analytic Hierarchy Process for Student Profile Analysis[108]	Criteria resulting in students' failure are analyzed.	1. Lack of motivation 2. Family instability 3. Lack of responsibility 4. Interaction with students 5. Financial problems 6. Absenteeism 7. The difficulty of French courses 8. Teaching skills of teachers 9. Addiction 10. The level of the French language 11. Insufficient material for practical work 12. Lack of continuous controls
11	Investigating Undergraduates' Perceptions of Employability Skills in the UAE: an Analytic hierarchy Process Model in Engineering and Business Students[109]	The author attempted to find the most important employability skills for UG students.	1. Communication 2. Teamwork 3. Problem-solving 4. Technology
12	Key Performance Indicators Measurement Model Based on the Analytic Hierarchy Process	Key performance measurement indicators for higher technical learning	1. Academics 2. Research 3. Supporting

	and Trend-Comparative Dimension in Higher Education Institution[110]	institutes are measured.	
13	The productivity of the Technical Education system using AHP[111]	Factors related to teachers, students, and management affecting the productivity of the education system are ranked.	1. Regularity of student 2. Academic Performance of 3. Student 4. Result of 12th std. of student 5. Qualification of faculty 6. Experience of faculty 7. Knowledge of faculty 8. Regularity of faculty 9. Library 10. Laboratories 11. Audio/Video Aid 12. Internet
14	Student Absenteeism in Engineering Colleges: Evaluation of Alternatives Using AHP[112]	Ranking of the crubs related to students absenteeism.	1. Frequent ill health 2. Monetary problems 3. Responsibility being taken up 4. Teacher 5. Motivation(self,parents, teacher) 6. Proper ventilation 7. Difficulty in changing from regional 8. language to English 9. Indiscipline 10. Evaluation system 11. Participation in cocurricular/ extracurricular/ cultural activities 12. Preparation for other courses
15	Study of Fuzzy-Ahp Model to Search the Criterion in the Evaluation of the	The criteria and subcriteria are selected based on the format mentioned by the National Board of	1. Campus Infrastructure 2. Faculty 3. Student 4. Academic Ambience

	Best Technical Institutions: A Case Study[113]	accreditation & through expert's opinion for evaluation of the technical institute	5. Teaching-Learning Process 6. Supplementary Process
16	A Hierarchical Model for E-learning implementation challenges using AHP by Shahid Farid et. al.[114]	Formulating a hierarchical model of the challenges affecting the integration of information and communication technology in Pakistan's HEIs.	1. Software 2. Technical 3. Institutional 4. Personal 5. Cultural
17	A framework of faculty performance evaluation: A case study in Bangladesh by CL Karmaker et al. [115]	Investigate the performance of academic staff and evaluate teachers' performance of the engineering university of Bangladesh.	1. Subject Knowledge 2. Ability of Communication 3. Discipline 4. Co-operative 5. Creative

The applications of AHP in the education field are summarised in Tables 5-1 and 5-2. The primary emphasis is on analyzing the issues of the stakeholders - students and staff. Following the identification of the area of application and the criteria considered for student and staff issues, an open-ended questionnaire is built in which they are asked to express their views on the education system in Indian higher technical education. The frequency of responses for the parameters highlighted in the above table was noted and further analyzed based on the feedback received in the following chapter.

5.2.1. DEVELOPMENT OF AHP MODEL RELATED TO EDUCATION

This section goes through the systematic process of defining parameters for the education sector using AHP. The procedure begins by outlining the overall hierarchy of the decision-making issue. The hierarchy is divided into three tiers: top (the overall goal of the problem), intermediate (criteria and sub-criteria on which subsequent levels are based), and bottom (the list of alternatives). Following the establishment of the hierarchy, pairwise comparison evaluation occurs. The requirements on the same hierarchy level are then compared to each of the previous (upper) level criteria. The pairwise comparison is graded on a scale of 0 to 10.

5.2.2. IDENTIFICATION OF CRITERIA AND SUB CRITERIA FOR EVALUATING ALTERNATIVES

One of the most crucial steps in the proposed model is determining all of the important parameters and their relationships with the decision variables. This phase is critical since the criterion and sub-criteria chosen will affect the final decision. The requirements and sub-criteria for this study are based on the expert's opinion, the references in Table 5-1, and the format specified by the National Board of Accreditation. Private government-aided technical institutions and the self-financed Sandip University in Nashik, Maharashtra, India were chosen as alternatives. The criteria and sub-criteria are defined in Table 5-3.

Table 5-3: Criteria and Sub Criteria

Sr No	Criteria	Sub Criteria
1	Student	Admission, Academic Result, Placement
2	Faculty	Staff/ Student ratio, Qualification/ Experience of Faculty, Faculty retention
3	Teaching-Learning Process	Syllabus coverage, Remedial class, Advance Teaching Aid, Industrial visits, Practical exposure, Exam Pattern, Innovation/ Research, and Development
4	Campus Infrastructure	Classroom, Laboratory, Library, Hostel, Transport/ canteen/ Internet, Power backup, Security, Wi-fi, Laundry, stationery Store
5	Supplementary Process	Alumni, Co-curricular activity, Cultural activity, seminar/workshop, Counselling, Time Management, Caste/category, Finance

5.2.3. CONSTRUCTION OF THE DETAILED HIERARCHY OF THE PROBLEM

The construction of the hierarchy considers all of the criteria and sub-criteria that are unique to the research issue. From the top (performance evaluation of technical institutions) to the intermediate levels, the hierarchy structure is as follows: (main and sub-criteria on which subsequent levels depend). The hierarchy is depicted in detail in Figure 5-1.

The criteria and subcriteria derived from the available literature will be validated by conducting the survey and examining the frequency of responses. The stepwise solution for the AHP model mentioned in Chapter 3 can be used to solve it further by collecting data from Sandip University students and faculty through a survey.

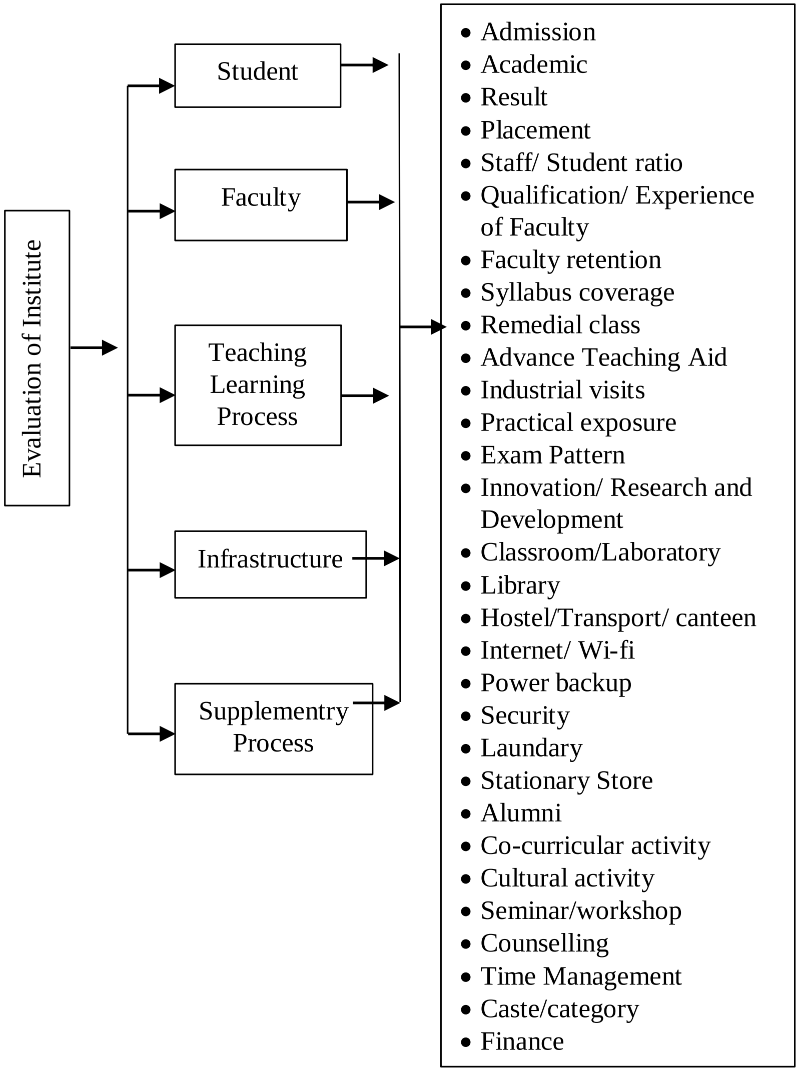

Figure 5-1: Detailed hierarchy of the Education Institute and Criteria

The aim is to use a TPM-based model to solve problems found through student feedback. Chapter 6 proposes a model based on the data examined by tracking the frequency of the above-mentioned criteria.

CHAPTER 6. ENHANCING THE PRODUCTIVITY OF TECHNICAL EDUCATION IN INDIA

6.1. INTRODUCTION

Since ancient times, India has had a traditional Gurukul Parampara of teaching. Kings used to send their princes to Gurus in Ashrams, which were typically located in the forest, to learn various techniques. The conventional teaching-learning process is gradually being replaced by digital technologies based on ICT. It does, however, have a number of disadvantages. Particularly when we consider the most recent employability ratio [116], it is too low. If we concentrate on technical education, just about 31% of engineers are employable. These show the need for analyzing the system..

Technical education has seen lots of changes in the last few decades. Implementation of Outcome-Based Education(OBE) along with various case studies are available[117]. Education culture is marching towards digitization. As per the analysis of the IEEE EDUCON 2014-2016 conference papers, the digitalization in engineering education is increasing [118][119]. Literature shows the reflection of digitization from the topic of research to teaching methodology [119]. Smart learning is upcoming to compile education with industry 4.0 [120]. "Digitalization means the transformation of all information types (texts, audio-videos, visual presentations, and other data from various sources) into the digital language" [121]. Future classrooms will be dealing with students' minds in terms of innovation and creativity and out of box thinking. Students will not only memorize and reproduce theory in test papers but also apply it logically [121]. A modern classroom is an Information and Communication Technology-based (ICT) classroom. Traditional classes are getting converted into interactive sessions by combining the best hardware with syllabus-compliant multimedia content [122]. A virtual learning experience finds its practical use in the digital transformation of engineering education [123]. Digital teaching-learning gives better results but also has some challenges [124]. Blended learning is also a useful teaching-learning tool in the modern era [125]. As the employability ratio is less, it is required to provide skill-based training in the curriculum, obtained by imparting engineers with business managerial skills due to the requirement of techno managers for future industries[126].

Dawar et al. discussed a few challenges in higher education concerning different stakeholders – teachers, students, industry, parents, etc. [127].

The role of women in developing higher education is also very significant. The purpose of all the stakeholders related to higher education is to be considered and studied at the secondary level. Shinde et al. analyzed the root cause of problems related to staff and students[18][128]. Further, he suggested the solution to the problem related to stress as Yog Nidra in one of the papers [129]. The capsule of Yog Nidra is the same in the historical background, whereas Hinduism and Buddhism are aware of this technique. Lord Krishna is often associated with Yog Nidra. It is helpful to get relief from headaches, giddiness, chest pain, palpitations, sweating, and abdominal pain, which respond well. It might be beneficial for soldiers having stress disorder in War[130]. Shinde et al. demonstrate the essential benefits of Yoga to enhance productivity in students [16] in their case study at Sandip University.

Yog-Nidra or Yogic sleep is a powerful meditation technique. The practitioner has to lie down on the back and rest in Savasana (corpse pose). It takes you to Pancha Maya kosha (five layers of self) with a sense of wholeness. Children to seniors at any age can practice this. Time is not the limit; it can be as short as five minutes to as long as one hour. It promotes deep relaxation, calms the nervous system[130].

The focus is to analyze the shortcomings in the education system, map them with the losses in industries, and propose solutions in the form of the TPM tool.

Students have an issue with assignments feeling that they have to solve excessive assignments. Assignments, which will reflect their abilities, are considerable, although just writing for tasks does no good. In engineering education, excessive assignments play a crucial role in wasting the student's time, as students are just copying it for the sake of submission. However, if replaced with this unnecessary work, a good assignment will help improve Indian engineering education. It needs a different technique to get things done more practically oriented, which can be done by Problem Based Learning (PBL).

Secondly, the exam pattern is a prime issue in understanding the difficulty of getting good grades in the exam. Every student’s perception of getting adapted to the education system is different, and also the estimated time for getting adjusted to the system may differ. This difference often results in failure or a significant setback for the student. To attempt an exam, the student should understand the examination pattern. Many exam patterns – marking/evolving methods have changed in universities over time, confusing the student to a greater extent. Students take time to understand the exam pattern, which results in their graduation. They focus on scoring in exams, but the actual conceptual study is missing. Thirdly, timetables play a crucial role in any academic system. A well-designed calendar is always a key to more success stories in engineering education. Calendars can be of the exam as well as the daily scheduled lectures.

The academic timetable should account for the essential workload as defined by the university, as well as the students' co-curricular and extra-curricular activities. It should also recognise the time needed for student updating and bridging the gap between syllabus and current recruiter requirements. Both timetables should be prepared to meet all standards while still being student-friendly. They should be structured with students in mind, taking into account their studies and jobs.

Another important consideration is the teaching-learning process. The most recent teaching-learning methods, such as PBL, e-Learning, and ICT, should be used. For the best results in the Indian education system, combine traditional teaching approaches with these modern techniques.

Similar to the requirements of materials in industries, resources are necessary for education. One of the causes of student’s failure is resources. This cause highlights the various shortcomings as college infrastructure, variation in students' merit and tradition, books, journals, etc. The college infrastructure plays a vital role in the education of the students, and if it's not well built, then there will be obstacles in the overall development of the student. Some of the most basic necessary elements that a college campus should have are well-equipped classrooms and laboratories, as the norms mentioned by the university syllabus.

A library with sufficient books, journals, newspapers, magazines, an e-library with access to online books and journals proves to be an essential aid in education.

Classmates are also a significant reason for the student to create interest in the curriculum. If the college crowd is not good as few of the students are not study-oriented, they affect performance as they might distract the student's focus from the studies and divert it elsewhere. It happens if there is a vast difference in students' merit during intake. Campus placement also plays a significant role. Also, access to industries through industrial visits, expert lecture series through the industrial person, in-plant training, internship, projects play an essential role in the overall growth of the students. Some colleges fail to do so even they are advertising; this decays the morale of the students.

The role of universities is crucial as it controls the entire educational structure and policies. Curriculum design is the most critical parameter. The updated syllabus is the heart of the curriculum. The examination system and evaluation system also affect the output of the students.

As discussed in previous chapter 5 (section 5.2), the inputs are taken from the AHP applied for the education sector to enhance the quality of technical education, identifying the criteria and subcriteria. Based on this, AHP is used to determine the problems and then further formulate pillars for the TPE model. A survey-based analysis is proposed in this chapter to check their frequency of responses and to validate them. The responses were noted in terms of problems/suggestions given by the students and faculties in response to the open-ended questionnaire floated to them. Fig. 6-1 shows the proposed model for Total Productive Education, showing the criteria and sub-criteria required as per AHP.

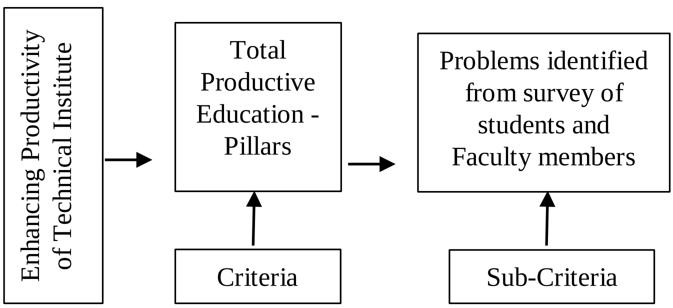

Figure 6-1: AHP for Formulation of TPE model

6.2. DATA COLLECTION

As discussed in section 5.2.2, the criteria identified from AHP for the education sector are analyzed. The survey was conducted in March 2018 to investigate the quality of technical education in Indian Universities. The base of the analysis is the data collected through a survey for staff and students. The staff is from various engineering departments from different institutes, and students are from the second year to the final year of four years of an engineering program. The students selected were from the engineering institutes belonging to different Universities in Maharashtra, India. The open-ended questionnaire floated to the students (as described in chapter 4), and the data collected from nearly 2769 students. The data then sorted for further processing. Students were free to write their opinion.

The survey was conducted for the students from two universities from Maharashtra, India. Viz., Sandip University from Nashik, and the University of Pune from Pune. Institutes that participated were from Sandip University – School of Engineering and Technology (SOET), and from the University of Pune – Sandip Institute of Technology and Research center (SITRC) and Sandip Institute of Engineering and Management (SIEM).

From the above institutes, the number of responses received from students tabulated in Table 6-1 to 6-3 below:

Table 6-1: Number of responses received from SIEM (Year wise)

Institute: SIEM						
Sr No	Department	**Div.**	**SE**	**TE**	**BE**	Total
1	Electrical	A	64	36	40	140
		B	63		46	109
2	Computer	A	28	40	22	90
3	E & TC	A	43	28	31	102
4	Civil	A	48	37	40	125
		B	51	50	35	136
		C	68	55	42	165
5	Mechanical	A	54	61	62	177
		B	58	50	40	148
		C	43	55	44	142
		Total	**520**	**412**	**402**	**1334**

Table 6-2: Number of responses received from SITRC (Year wise)

Institute: SITRC						
Sr No	Department	**Div.**	**SE**	**TE**	**BE**	Total
1	E & TC	A	15		12	27
		B	38	27	10	75
2	IT	A	53	44	38	135
3	Mechanical	A		56	110	166
		B	32	51		83
4	Computer	A	64	52		116
		B	58	51		109
5	Electrical	A	18	45	21	84
		B	32	25	23	80
6	Civil	A	37	49		86
		Total	**347**	**400**	**214**	**961**

Table 6-3: Number of responses received from SOET, SUN (Year wise)

Institute: SOET, SUN					
Sr No	**Stream**	**Div.**	**SE**	**TE**	Total
1	Computer	IBM	44		44
		CS	22		22
		IoT	15		15
		CTIS	42	15	57
2	Aerospace	A	73		73
3	Electrical	A	27	41	68
4	Mechanical	A		43	43
		B	7	51	58
5	Civil	A	36		36
		B	30	28	58
		Total	296	**178**	**474**

Analysis of the Sample: The survey was planned for 3000 students, out of which 2769 students responded, giving a response rate of 92.3%. The comparisons and conclusions were drawn as per the analysis considering different data sets of the students.
The summary of the respondents in Table 6-4.

Table 6-4: Summary of responses received from all institutes (Year wise)

Summary of Responses collected				
Institute	**SE**	**TE**	**BE**	**Total**
SIEM	520	412	402	**1334**
SITRC	347	400	214	**961**
SOET	296	178		**474**
Total	**1163**	**990**	**616**	**2769**

6.3. METHODOLOGY

The response data collected from the students are analyzed in the subsequent sessions to focus on the issues, identify the problems, and suggest the solutions to minimize the same. As discussed in chapter 5, the open-ended questions are float to the students, and the responses are noted as per the criteria mentioned in Table 5-3. Few other problems noticed in feedback, other than the criteria, are also considered for analysis.

Characteristics of the respondents: The respondents characterized in terms of:

1. Institute of Students
2. Branch/Course student appears.
3. Level of student / Year of the course appearing for – Second to Final year.
4. University of the students.

6.4. ANALYSIS OF DATA

The initiative's primary objective is to enhance productivity in higher technical education revealed from the analysis of the data collected. The criteria from Fig.5-1 were considered while analyzing the data. The criteria whose frequency of response was noticeable were shortlisted and shown in Fig. 6-2. The analysis resulted in categorizing the student's feedback into prominent thirteen characteristics selected from criteria in Table 5-3 and Fig. 5-1, to be focused on enhancing technical education as shown in Fig. 6-2, and the frequency of responses tabulated in Table 6-5:

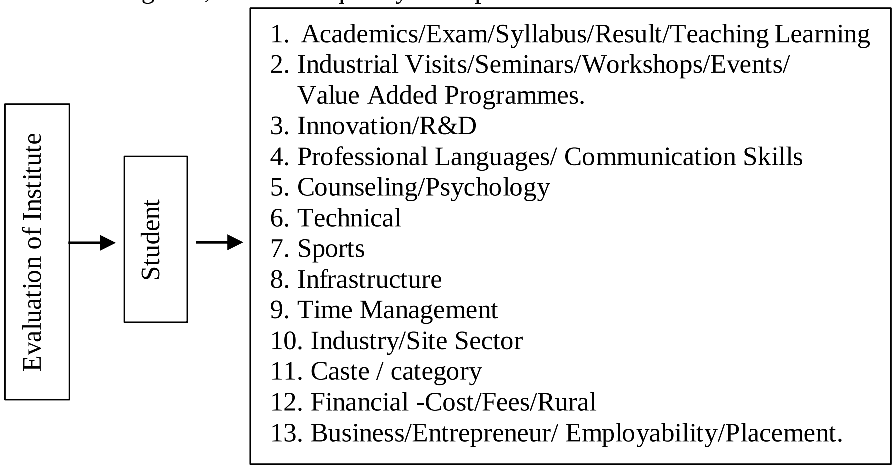

Figure 6-2: Detailed hierarchy of the student's problem

6.5. RESPONSES COUNTED FOR CHARACTERISTICS IDENTIFIED

Table 6-5: Responses to various characteristics from students of SITRC, SIEM and SOET, SUN

Student Strength and Responses Obtained from Students		SUN	SIEM	SITRC	SIEM+ SITRC	TOTAL
	Student Strength ==>	**474**	**989**	**863**	**469**	
No	**Characteristics**	**Number of Responses**				
1	Academics	**836**	**843**	**2064**	**642**	**4385**
2	Industrial visits/Seminars/WS/ Events/Co-Curricular activities	**254**	**243**	**463**	**160**	**1120**
3	Innovation/ R & D /New Technology	**112**	**82**	**151**	**36**	**381**
4	Professional Languages / Soft Skills	**19**	**32**	**51**	**7**	**109**
5	Counselling / Psychology/ Human: Mind and Body / Stress	**4**	**27**	**11**	**10**	**52**
6	Technical	**13**	**15**	**23**	**5**	**56**
7	Sports	**29**	**14**	**18**	**7**	**68**
8	Infrastructure / Books/Labs/Wi-Fi/smart Class room/ Library	**104**	**19**	**55**	**10**	**188**
9	Time Management / Attendance / Exam Time table	**115**	**41**	**244**	**25**	**425**
10	Industry / Site Sector/ Abroad	**1**	**49**	**10**	**7**	**67**
11	Caste / category	**36**	**43**	**31**	**5**	**115**
12	Cost/ fees/ Rural/ Finance / Scholarship	**0**	**34**	**5**	**0**	**39**
13	Business / Entrepreneur/ Employability	**30**	**42**	**59**	**23**	**154**

6.5.1. ANALYSIS OF RESPONSES

The responses noted in Table 6-5 are analyzed in this chapter, as shown in Table 6-6, considering different data sets.

Table 6-6: Responses to various characteristics from students institute-wise

Sr. No		SIEM	SITRC Total	SUN Total	Total
	Student Strength ==>	989	863	408	2729
1	Academics	843	2064	836	4385
2	Industrial visits/ Seminars/ WS/ Events/ Co-curricular activities	243	463	254	1120
3	Innovation/ R & D /New Technology	82	151	112	381
4	Professional Languages / Soft Skills	32	51	19	109
5	Counselling / Psychological/ Human: Mind and Body / Stress	27	11	4	52
6	Technical	15	23	13	56
7	Sports	14	18	29	68
8	Infrastructure / Books/Labs/Wi-Fi/smart Class room/ Library	19	55	104	188
9	Time Management / Attendance / Exam Time table	41	244	115	425
10	Industry / Site Sector/ Abroad	49	10	1	67
11	Caste / Category	43	16	36	100
12	Cost/ fees/ Rural/ Finance / Scholarship	34	20	0	77
13	Business / Entrepreneur/ Employability	39	59	30	133
14	Positive Feedback/ Blank/ Not valid	103	5	53	192

The graphical representation of the response values obtained for various characteristics, considering different parameters shown in Fig. 6-3 to 6-5.

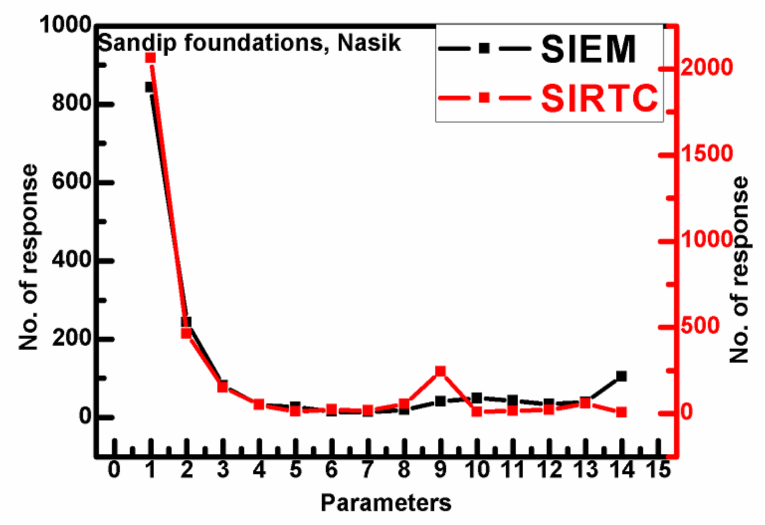

Figure 6-3: Responses from SIEM and SITRC students

Fig. 6-3 shows the graphical comparison between two institutes affiliated with the same university. The difference reflected is in point no nine due to the freedom given for attendance, time management, and assignments assessed by the institute. Rest points are related to University reflects with the same frequency of response. Positive feedback regarding the institute indicated, as shown in point number fourteen.

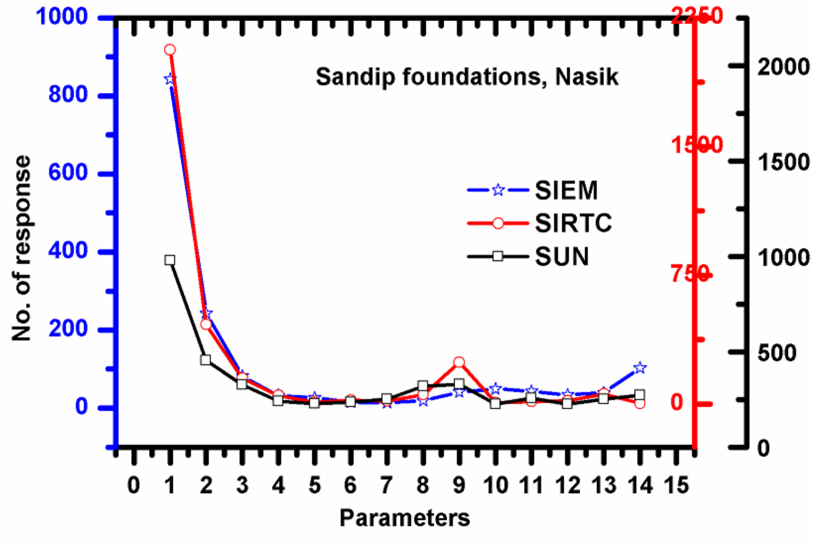

Figure 6-4: Graphical representation for the responses to various characteristics from students of SIEM, SITRC & SOET, SUN

Irrespective of the student's course, level of the semester, institute, or university, the overall response is similar. Response to the problems raised by the students from all levels from any course or university is nearly identical.

Fig. 6-4 shows that significant responses are related to academics. Comparing institutes, the intensity of problems overall is similar. The frequency of response from SIEM and SITRC from the University of Pune is the same. Still, it slightly differs in few parameters depending on the quality delivered and maintain by institutes. Standard parameters like syllabus, which are similar to both the institutes, as per Pune University, have the same frequency of response. But if we compare it with another university, i.e., Sandip University differs. Irrespective of the university, specific parameters like teaching-learning, placements depend on the institute's performance.

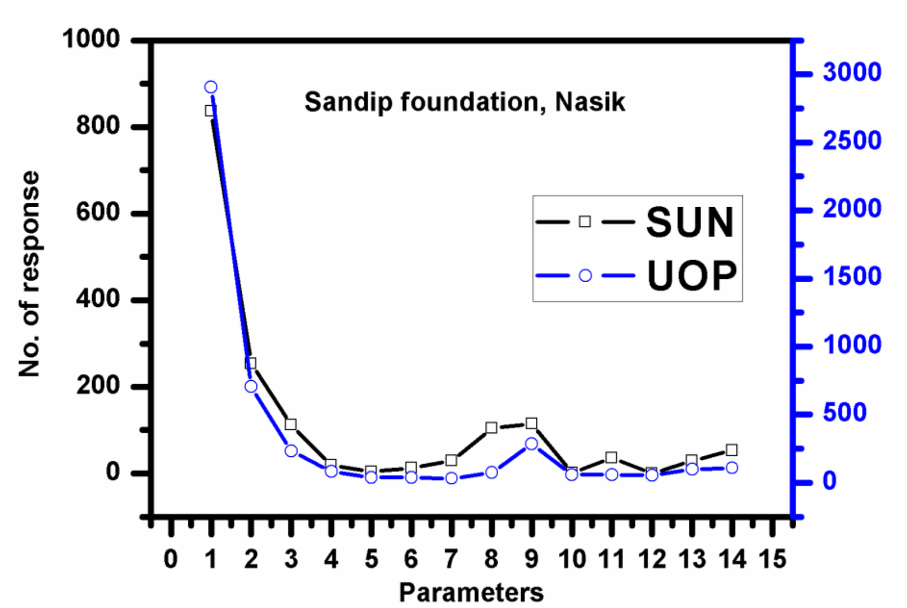

Figure 6-5: Graphical representation for the responses to various characteristics from students of different Universities.

Fig. 6-5 shows the graphical representation of students from different universities. The significant difference noted in point 1 is due to curriculum revision. In point 3, due to new technology upgrades in the curriculum of Sandip University. In point 8, due to the infrastructure and facilities provided. Point 11, caste scholarships are given. Point 14 reflects overall positive feedback from the students of Sandip University.

6.5.2. ACADEMIC

From the response Table 6-2, academics play an important role as most of the responses are related to academic issues. A detailed analysis of the academic parameters is done and tabulated below in Table 6-7.

Table 6-7: Responses regarding academics from students of SIEM, SITRC, and SUN.

		SIEM	SITRC	SUN	TOTAL
	Student Strength ==>	989	633	408	2030
Sr No	Academic Characteristics	No of responses Responses			
	Academics	843	1585	836	3264
1	Syllabus/curriculum	318	365	127	810
2	Therotical/Practical Knowledge/ Project work/ Skills/ PBL	240	538	431	1209
3	Exam/Marking scheme/Pattern/CIA	111	354	81	546
4	Teaching Learning process/ Submission/Staff/ Digitilization/ Assignments/Learning material	174	328	197	699

The academics elaborated on different characteristics; the critical part is syllabus designing, up-gradation, and implementation. Then comes the delivery pattern of the contents. Most of the students responded to have more practical base knowledge than theory lectures. The students demand project base, practical-based, and skill-based learning. Next is the issue with the submission of assignments for the subjects. And finally, the teaching-learning process.

Outcome-Based Education pattern suggested and implemented to overcome these issues in Sandip University. The assignments were replaced by experiential learning. Project-based learning is applied to create interest and clear the basic fundamental of the students. The results obtained are remarkable. The performance of the students is improved, and the attendance ratio of the students has increased.

In Sandip University, as a part of the implementation of OBE and other teaching-learning tools, students performed various tasks. Groups were formed, and students were given the task to prepare the simple conceptual model of the subject they learned. Final and pre-final year students are giving projects as a part of PBL and ABL. As an example, Fig. 6-6 shows the experiential setup prepared by students to perform practicals. First-year students are making simple models, as shown n Fig. 6-7 & 6-8, to clear their basic concepts.

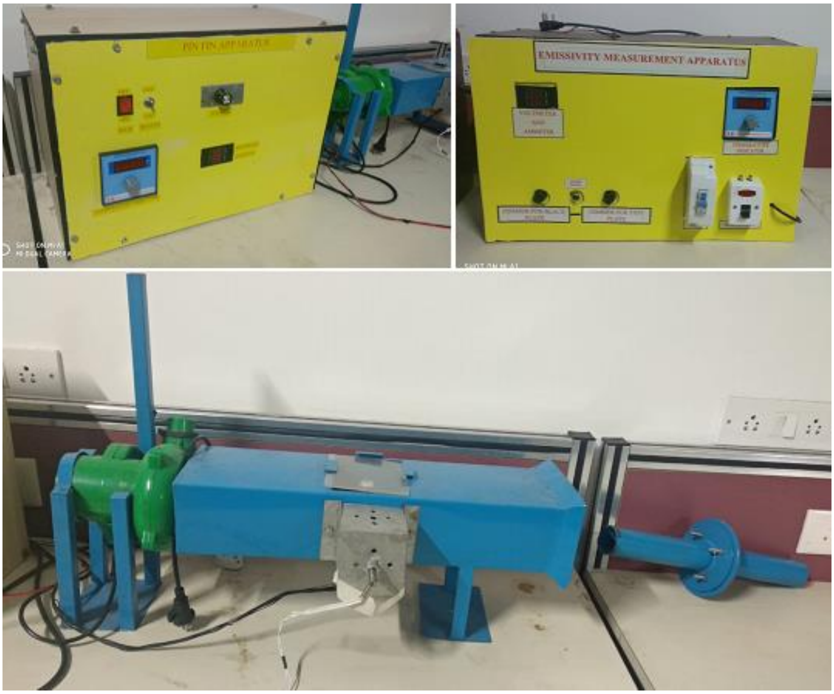

Figure 6-6: Experimental set-up prepared by students

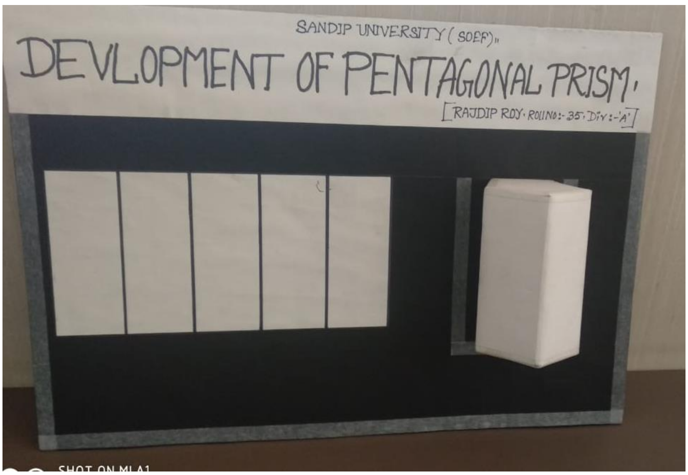

Figure 6-7: Model to show the development of solid as a part of experiential learning

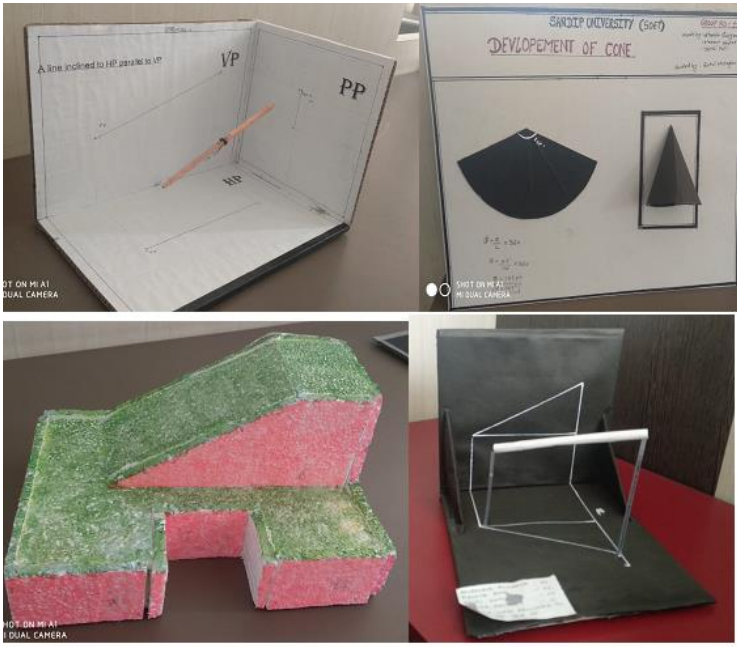

Figure 6-8: Models prepared as a part of experiential learning

Fig. 6-7 & 6-8 shows the models prepared by first-year engineering students for the subject Engineering Graphics. They learn the concept of projections, development, and sectional views in their curriculum.

6.6. PARETO CHART FOR CHARACTERISTICS

Data for 2096 students analyzed for the subdivision of academic characteristics, as shown in Table 6-8. Pareto char drawn shows percentage response and cumulative response in Fig. 6-9.
The Pareto chart is named after Vilfredo Pareto, the creator of the "80/20 law," which states that generally speaking, 80 percent of losses are caused by 20 percent of the causes in terms of quality. A Pareto Chart depicts the frequency of responses to problems as well as the combined effect of those responses. It emphasises the most significant of a wide number of variables. It is useful to identify the problems to prioritise in order to see the most important overall change. It visually depicts the condition is more important by graphically representing the percentage value of the problems from largest to smallest in a bar graph. It aids in visualising the factors constitute the crucial 20%—the "vital few"—and which are the "trivial many." A cumulative percentage line in the chart aids in determining the additional contribution of each characteristic. The steep rise in the first few characteristics demonstrates the existence of the Pareto effect.

Table 6-8: Number of responses for 2096 students for Pareto chart

Sr No.	Characteristics	Responses	% Response	Cum %
1	Theoretical/Practical Knowledge/Project work/Skills/PBL	1209	21.93	22
2	Industrial visits/Seminars/WS/ Events/Co Curricular activities	855	15.51	37
3	Syllabus	810	14.70	52
4	Teaching Learning process/ Submission/Staff/ Digitalization/ Assignments/Learning material	699	12.68	65
5	Exam/Marking scheme/Pattern/CIA	546	9.91	75
6	Time Management / Attendance / Exam Time table	360	6.53	81
7	Innovation/ R & D /New Technology	309	5.61	87
8	Infrastructure / Books/Labs/Wi-Fi/smart Class room/ Library	171	3.10	90
9	Business / Entrepreneur/ Employability	116	2.10	92
10	Caste	109	1.98	94
11	Professional Languages / Soft Skills	89	1.61	96
12	Sports	59	1.07	97
13	Industry / Site Sector/ Abroad	59	1.07	98
14	Technical	46	0.83	99
15	Counselling / Psycological/ Human: Mind and Body / Stress	40	0.73	99
16	Cost/ Fees/ Rular/ Finance / Scholarship	35	0.63	100
	Total:	5512	100	

Pareto chart in Fig. 6-9 shows that the significant responses are related to academics parameters – Therotical Approach & Syllabus. The secondary concern is about the activities – industrial visits/seminars, etc., to be conducted. The characteristics of having less response can be merged with others to form the pillar of the Total Productive Education System (TPE). Referring to Fig. 6-9, Pareto shows that students are more concerned about the points related to their academics and examination. While developing the TPE model, the area to focus on will be 20 percent causes raising 80 percent of problems. More focus to be given on the academics of the students. The characteristics at the end of the graph are of low frequencies, so these characteristics can be merged to construct the TPE pillar. Prioritization of the factors while designing the TPE model is done with the help of the Pareto chart.

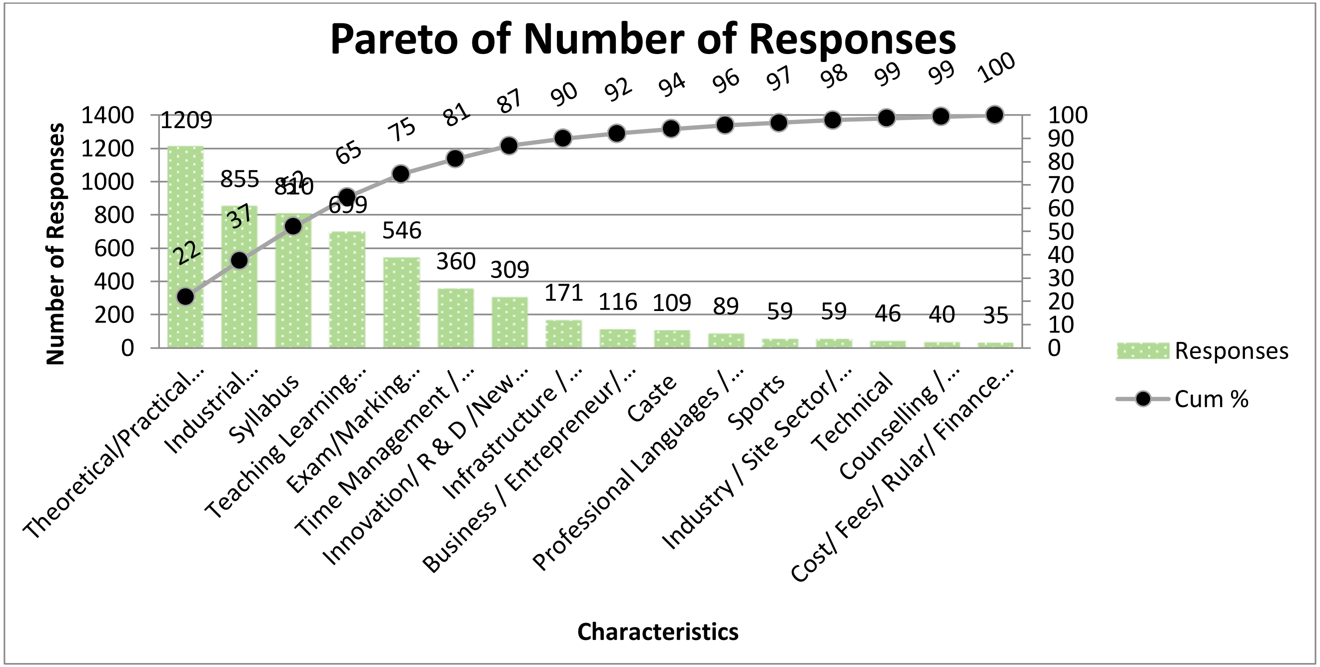

Figure 6-9: Pareto chart for the number of responses

6.7. DISCUSSION ON VARIOUS CHARACTERISTICS

The above responses monitored are analyzed, and the solution for the same is suggested and implemented in Sandip University, Nashik, as a case study.

6.7.1. PROBABILITY INDEX

In today's era, education is the foremost important to enhance productivity in students for the technological world. The primary aim is to identify the root cause of the failure of the engineering education system to make graduates employable. It aims to support the Skill India, Make in India, and Yoga day initiatives of the Indian government, by providing an Industry ready and highly skilled workforce to increase manufacturing in India. It aims to establish the relationship between teachers, scholars, and other educational leaders to promote citizenship in free societies. It seeks to attract more students to technical education by increasing employability, by initiating start-ups, by doing research and innovation for building Nation.

Data Used: Mixed data of 2729 students is used for this analysis amongst the entire data collected. The data is irrespective of the year, program, and institute of the students.

Table 6-9: Responses of 2729 students from SIEM and SITRC engineering institutes

Sr. No	Number of Responses: 2729 Student Strength ==>	2729
1	Academics	4385
2	Industrial visits/Seminars/Workshops/ Events/Co-Curricular activities	1120
3	Innovation/ R & D /New Technology	381
4	Professional Languages / Soft Skills	109
5	Counselling / Psychological/ Human: Mind and Body / Stress	52
6	Technical	56
7	Sports	68
8	Infrastructure / Books/Labs/Wi-Fi/smart Class room/ Library	188
9	Time Management / Attendance / Exam Time table	425
10	Industry / Site Sector/ Abroad	67
11	Caste	100
12	Cost/ fees/ Rural/ Finance / Scholarship	77
13	Business / Entrepreneur/ Employability	133

Characteristics of the respondents: All the students are of the UG level of engineering institutes.
The probability indexes that directly influence the student-teacher relationship in the technical education system are defined. A generalized formula is used based on the probability index to solve academics and its core values, directly influencing the students, equation no. 1. Based on a survey, data collected from many students, out of which data of 2729 students were analyzed to solve this problem for technical education. However, the rating has been done based on averages.

The higher the weightage, the higher the number given "A" with decreasing order of purely English alphabet, respectively. This capsule decided the primary function for technical education in the previously mentioned application.

$$H = \frac{[(k-n)x_n + \sum_{n=1}^{k} x_{n+1}]}{2(k-n)} \quad \text{...} \; (3)$$

H = Function of Probability index
K = number of parameters (13 in this case)
n = integer (non-zero positive)
x = mean average

From the probability distribution index as in equation -3, we have calculated the index values of all ratings for all the technical colleges in Sandip, Nasik. It is a fundamental formula to study the functions of the different variable parameters of the overall educations pillar.

Referring to Table 6-10 for Probability index: Firstly, it calculates the probability index (H) function. Then the average of the responses calculated in column 2, by dividing the number of responses from column 1 by the total number of responses, i.e., 2769. Then column 3 and after that, calculated by taking the average of the current row and next row value. In the end, the average values of the values in the row are calculated to get the probability index.

Table 6-10: Probability index

	Number of Responses:	2729																
Sr No	Paramters	No. of Responses													Probability Index		Rating
1	Academics	4385	1.6068														1.607	A
2	Industrial visits/Seminars/WS/ Events	1120	0.4104	1.0086													0.710	B
3	Innovation/ R & D	381	0.1396	0.8732	0.2750												0.429	C
4	Professional Languages	109	0.0399	0.8234	0.2252	0.0898											0.295	D
5	Counselling / Psycological/ Human: Mind and Body	52	0.0191	0.8129	0.2147	0.0793	0.0295										0.231	E
6	Technical	56	0.0205	0.8137	0.2155	0.0801	0.0324	0.0198									0.197	G
7	Sports	68	0.0249	0.8159	0.2177	0.0823	0.0544	0.0220	0.0227								0.177	I
8	Infrastructure	188	0.0689	0.8379	0.2396	0.1043	0.0978	0.0440	0.0447	0.0469							0.186	H
9	Time Management	425	0.1557	0.8813	0.2831	0.1477	0.0322	0.0874	0.0881	0.0903	0.1123						0.209	F
10	Industry / Site Sector	67	0.0246	0.8157	0.2175	0.0821	0.0383	0.0218	0.0225	0.0247	0.0467	0.0901					0.138	J
11	Caste	100	0.0366	0.8217	0.2235	0.0881	0.0341	0.0278	0.0286	0.0308	0.0306	0.0962	0.0306				0.132	K
12	Cost/ fees/ Rular	77	0.0282	0.8175	0.2193	0.0839	0.0443	0.0236	0.0244	0.0266	0.0486	0.0920	0.0264	0.0324			0.122	M
13	Business / Entreprenuer	133	0.0487	0.8278	0.2296	0.0942	0.1209	0.0339	0.0346	0.0244	0.0588	0.1022	0.0366	0.0427	0.0385		0.130	L
	Probability Index		0.2018	0.8458	0.2328	0.0932	0.0538	0.0350	0.0380	0.0406	0.0594	0.0951	0.0312	0.0376	0.0385		4.562	

It is the fundamental tool to enhance productivity at Sandip University, Nasik, which might be useful in student and teacher relationships. The basic concept of the probability index is followed. On this basis, the rating is given as a case study, i.e., a practical approach to solve the issue. Also, to address the psychological needs of the students, they are advised to practice Yoga regularly, which is helpful to enhance the basic needs of the Human: mind and body [16]. Fig 6-10 shows the implementation of Yoga at Sandip University.

Figure 6-10: Students practicing Yoga

6.7.2. POWER LAW

In today's era, education is the foremost important to enhance productivity in students for the technological world. The power-law directly influences the rating of the students-teacher relationship in the technical education system. The generalized formula is introduced based on power law to analyze academics and their core values, directly influencing them. Moreover, in this case, data from 1800 students is considered to solve technical education [131]. With the help of power-law, the responses are plotted in a linear graph, making it convenient to analyze the critical area.

Table 6-11: Power-law for the technical education system

Sr No	Paramters	No. of Responses		log(μ)=log(K)+B*log(A)				
1	Academics	642	2.8075	1802.4375	-0.30103	1802.13646		
2	Industrial visits/Seminars/WS/ Events	160	2.2041	352.6592	-0.3010	352.3582		
3	Innovation/ R & D	36	1.5563	56.0269	-0.3010	55.7259		
4	Professional Languages	7	0.8451	5.9157	-0.3010	5.6147		
5	Counselling / Psycological/ Human: Mind and Body	10	1.0000	10.0000	-0.3010	9.6990		
6	Technical	5	0.6990	3.4949	-0.3010	3.1938		
7	Sports	7	0.8451	5.9157	-0.3010	5.6147		
8	Infrastructure	10	1.0000	10.0000	-0.3010	9.6990		
9	Time Management	25	1.3979	34.9485	-0.3010	34.6475		
10	Industry / Site Sector	5	0.6990	3.4949	-0.3010	3.1938		
11	Caste	7	0.8451	5.9157	-0.3010	5.6147		
12	Cost/ fees/ Rular	23	1.3617	31.3197	-0.3010	31.0187		
13	Business / Entreprenuer	5	0.6990	3.4949	-0.3010	3.1938		
	Power law							
	Rating		H	B	G	N	P	Q

Herein, power law has been transferred to straight lines so that it is easy to calculate different parameters.
The present study proposed the model of the three case studies to enhance the productivity of the three vertexes in the triangular model.

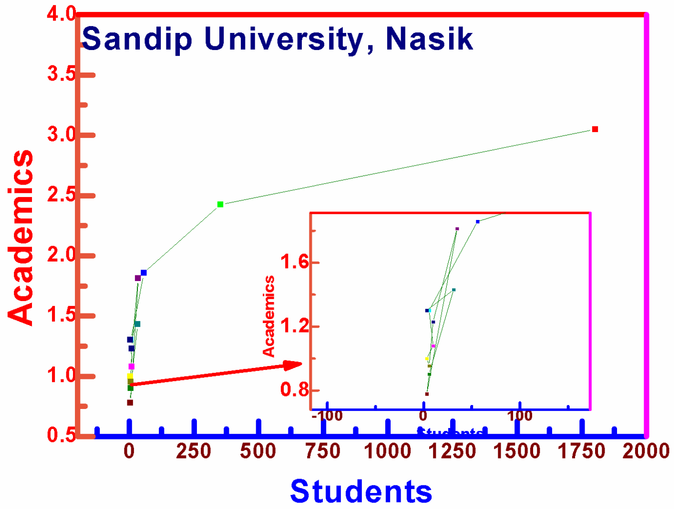

Figure 6-11: Non-linear curve indicates three vertexes that obey power-law during the case study in Sandip University, Nasik.

Based on the model, the logarithmic curve is plotted in terms of straight lines, Fig. 6-11 [131], which predicts the academic requirements in the students with the help of software Origin 8.0. Although in the initials terms up to 500 students, academics requirements directly follow a power law in which they are directly proportional. As we move on the further study, the academics requirements between three vertexes increase up to 2.7; it believes that the academics curriculum is beneficial to the students of the currents batch of the Sandip University, Nasik. Herein, a triangular model is suggested, which is rotational to itself with three degrees of freedom, i.e., Faculty, Students, or Academics.

On this basis, effective efficiency of the students using power law is introduced:-

η =(x1+ x2+x3)*100/1800 - …………………………………………………… (4)

Where x1 = coordinate of one vertex in the triangular model,
x2 = coordinate of the second vertex in the triangular model,
& x3 = coordinate of second vertex in triangular model
η = 36-45 %

It indicates that the outcome-based education's effective efficiency has increased from 36.8 % in Sandip University, Nasik.
The generalized formula based on the probability index to solve these Academics and its core values directly influences the students, equation no.-1 is mentioned. The rating has been done based on averages. The equations of modulus for obtaining resultants Students Performance Index (SPI) for SIEM – 438 students database given by:-

$$\text{SPI}=\frac{\sqrt{\sum_{i=1}^{n}(U_{ASi}*G_i)^2}}{\sqrt{\sum_{i=1}^{n}{U_{ASi}}^2}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

$$\text{SPI} = \frac{\sqrt{(642\times10)^2+(160\times6)^2}}{\sqrt{(642^2+160^2)}}$$

SPI = 9.8

$$\eta = \frac{x_{SPI-}x_{PU}}{x_{SPI}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

$$\eta = \frac{9.8-9.67}{9.8}$$

η = 1.3

The SPI for SIEM calculated using a modified version of the formula had obtained the root square data for finding the total semester Index. For further progress, a three-dimensional model indicates where is lagging and exceeds behind the students of the Technical system using the base model of Pune University. The probability system is the parameter to define the grading index of a total number of students with SPI. Herein, a model with different orientations in three dimensions is shown. The difference of their function used in their X-axis, Y-axis, Z-axis coordinate system such as f(x-x1, y-y1, and z-z1) is the incremental coordinate be useful for three dimensions representation of the Semester Performance Index.

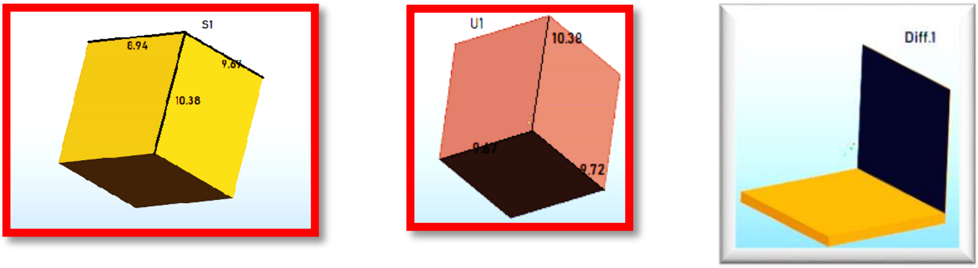

Figure 6-6-12: The 3D modeling using the software SolidWorks

3D modeling is done using the software - Solid Works. The S1, U1, and Diff1 indicate the 3D model concerning S1(SIRTC-SE, SIEM-SE, SUN), U1(SIRTC-TE, SIEM-TE, SUN), and Diff1f(S1-U1). Shown in Fig.6-12, (a) S1 for the extrude of (SIRTC-SE, SIEM-SE, SUN), (b) U1 for the extrude of (SIRTC-TE, SIEM-TE, SUN), (c) Diff1 for the difference of S1 & U1 respectively.

The tool used to design the model of how many students lagging and exceeding behind the SPPU to Sandip University, NASIK. From the data, calculated that the Quality of students is different and basic fundamental is weak. In Fig. 6-12, since the axis f(z) is removed out in the 3D model because they have the same values coming 10.38 dimension, this suggests that the overall quality of the students from outside Sandip University, Nasik & UOP are incrementally the same. So, this part was removed out from the model. However, the above equation is utilized to formulate the model that transformation of education numerically to 3D view. So, the primary aim is to have an easy and low-cost model to study the overall gap in the education system for private and government universities.

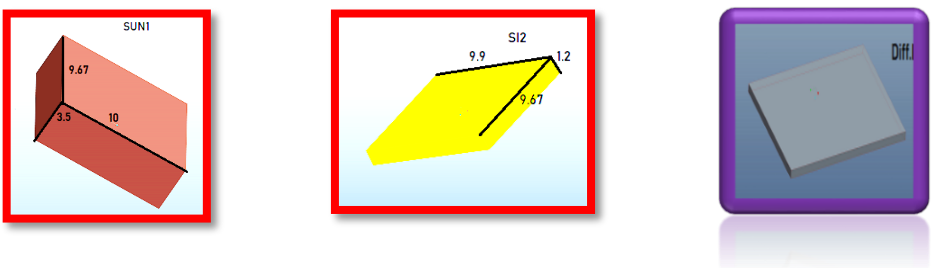

Figure 6-13: 3D model of efficiency for students at Sandip University, Nashik
(a) η1 for the extrude of SUN1 in all three directions, (b) η2 for the extrude of SI1 in all three directions and (c) Diff.I2 are difference of f(η1-η2).

Fig. 6-13 plots the η1(SUN1(x, y, z) and η2(SI2(x, y, z) as a 3D model concerning efficiency. It was calculated from the net change in efficiency divided by the output of efficiency for both models. The Diff1 f(η1 -η2) is the net output of the efficiency of the students for different engineering institutes have calculated efficacy, which lagging and exceeding the students to represent the 3D graphically. It helped to identify "What are the field student needs attention?" in a particular area. Our focus should be there to wipe out the problems during Technical rounds of interviews with the Industry manager. It is found to be more stable and increases the level of students where they are lagging and less technically strong. They can be pushed to a higher level having more robust, physically, and mentally to handle Industry and Academia.

6.7.3. STRESS RELIEVING

Human mind basics need to correlate with some yoga techniques such as Suryä Namaskar, chanting OM. Yoga is an excellent technique to relax the human body and mind. It would enhance the internal energy of the whole body. Although we know from the law of nature that the universe contains an infinite amount of energy to regain that energy in the human body chants OM, which interconnects with the mind-system and the world.

Table 6-12: Parameters and frequency of responses from students

	Responses from SIEM, Student Strength ==>	989
1	Academics	843
2	Industrial visits/Seminars/WS/ Events/Co Cirrucular activities	243
3	Innovation/ R & D /New Technology	82
4	Professional Languages / Soft Skills	32
5	Counselling / Psycological/ Human: Mind and Body / Stress	27
6	Technical	15
7	Sports	14
8	Infrastructure / Books/Labs/wi-fi/smart Class room/ Library	19
9	Time Management / Attendance / Exam Time table	41
10	Industry / Site Sector/ Abroad	49
11	Caste	43
12	Cost/ fees/ Rular/ Finance / Scholarship	34
13	Business / Entreprenuer/ Employbality	39
14	Positive Feedback/ Blank/ No Use	103

Table 6-13 considers the dataset of SIEM students. The student feedback analyzes the frequency of 14 parameters suggested by students to improve technical education. The findings indicate that academics play an important role in response to the student's feedback. The second significant findings are regarding industrial visits and workshops required.

A detailed discussion of these parameters done herewith:

1. Academics: Maximum students are discussing academic issues. The highest frequency of comments received related to academics. Therefore, it is analyzed and presented further in detail as tabulated in Table 6-14.
2. Industrial Visits/ Seminars/ Workshops/ Events/ Value Added Programmes - VAP/ Co Circular activities: This is another major parameter in the student's discussion. They urge for more industrial exposure and practical-based workshops, events, value-added programs (VAP) to be conducted to experience an actual industrial environment.
3. Innovation/ R&D/ New Technology/ Technical/ Industry/ Abroad: Students are also curious to learn new technologies, connect themselves in research and development, and go for higher studies in other countries. Research facilities and supervision is the need of the students. They should be given industrial projects and solve industrial problems as a part of their research projects with their professors. Research projects should be given to students to bring awareness regarding the industrial requirements and social impact [16] [14].
4. Professional Languages/ Communication Skills: Students should be given exposure to learning professional languages. Their communication skills should be enhanced.
5. Counselling/Psychological/ Human: Mind and Body / Stress/ Sports: The passing percentage of engineering graduates compared to intake is also significantly less in Indian Universities. Many students are psychologically depressed due to poor grades. The counseling of the students is a must. They should practice stress-relieving techniques such as meditation, Yoga, sports activity, etc., to refresh their mind and body. Fig.6-14 shows the implementation of Yoga as a stress-relieving tool for students. Similarly, they are trained for physical fitness, as shown in Fig. 6-15.

According to the analysis of the responses, characteristics no. 5, from Table 6-13, i.e., Counselling / Psychological/ Human: Mind and Body / Stress, is analyzed here in detail. While analyzing the data, the focus is on Counselling, Yog Nidra, directly related to the Mind, Brain, and Body. The five senses are essential to generate feelings and emotions. However, during the nastic application to cure Depression, Cancer, whereas Yoga science is a crucial tool for cancer treatment. We have taken the importance of raw data of Counselling/Psychological/Yog Nidra for the analysis.

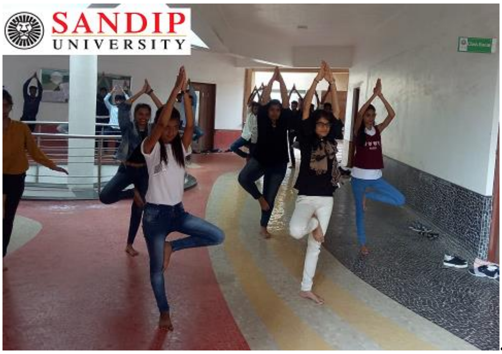

Figure 6-14: Students performing yoga at Sandip University, Nashik, India

Figure 6-15: Training of physical exercise to the students of Sandip University

6. Infrastructure / Books/ Labs/ Wi-Fi/ smart Classroom/ Library: Proper infrastructural facilities required by students like laboratories with all possible experimental setup, smart classrooms, digital platforms with audio-video facilities, a library with an adequate number, and a variety of books, journals, open sources, etc. Students also demand Wi-Fi to go for online courses and explore more through the latest e-resources available.
7. Time Management / Attendance / Exam Timetable: Students cannot manage time properly to attend the classes and take practical training. They don't want the constraint of attendance to attend theory classes. The exam timetable also plays a significant role in the student's performance. E-exams can also be taken in times to come [15]
8. Caste/ Cost/ Fees/ Finance / Scholarship: Few meritorious students, due to poor financial condition, cannot study. They need financial support. Merit students do not recommend Category-based scholarships in India. Education at an affordable cost will attract more students.
9. Business/ Entrepreneur/ Employability: Many students are worried about their employment, while a few are planning to start their business and be entrepreneurs. Maximum students should be motivated and supported to start their own start-up company. The government of India is supporting start-ups through the make-in-India scheme. There are many such options available.

Students' training is required for the same. Enhance entrepreneurship proposal for start-ups to master level students [16].

The significant responses observed are related to academics. So it is further analyzed in detail. The result is indicating the frequency of response shown in Table 6-14.

Table 6-13: Academic parameters and frequency of responses from students

Sr No	Parameters	Freq.
	Academics	843
1	Syllabus	318
2	Theoretical/Practical Knowledge/ Project work/ Skills/ PBL	240
3	Exam/Marking scheme/Pattern/CIA	111
4	Teaching Learning process/ Submission/ Staff/ Digitalisation/ Assignments/ Learning material	174

Based on the parameters, the corrective measures suggested, and few implemented in Sandip University.

1. Syllabus/ curriculum:

The major concern is in updating the syllabus. In many Universities, the syllabus up-gradation cycle is set to 3 to 4 years, whereas the technology is changing day by day. The syllabus should be updated as and when required, at least for a few branches, like computer engineering, the technology which changes frequently should be adopted in the syllabus immediately. Revision is necessary for the course structure, embedded theory, and practical pattern adopted for maximum courses. More weightage extended to practical training.

2. Theoretical/ Practical Knowledge/ Project work/ Skills/ PBL:

Students complaint is regarding theoretically based teaching. They want to have more practical training and exposure. So they should take industrial projects. Skill-based training to be imparted, Project-based Learning and Activity-based learning techniques should be adopted. The introduction of the "Practical Engineering" course integrated into the engineering bachelor program makes students prepared for working life [17].

3. Exam/Marking scheme/Pattern/CIA:

According to student feedback, more weightage to practical marks as compared to theory exams preferred. Revision requires in the marking scheme of the exam. Exam pattern affects the performance of students. Exam pattern like 80:20 (80% End semester exam, 20% internal assessment), 50:50 (50% End semester Exam, 50% online/in semester exam), 70:30, etc. are in use in India in different universities. Recommendation of Outcome-Based Education (OBE) for better teaching-learning methodology. This pattern has 50% weightage for the end semester exam and 50% for Continuous Internal Assessment (CIA), further divided into four components. This help student to study and being evaluated continuously—more emphasis on practical-based learning expected in this scheme. For improvement of results, the supplementary exam is introduced.

4. Teaching-Learning process/ Submission/ Staff/ Digitalization/ Assignments/ Learning material:

Another parameter that affects the quality of technical education is the teaching-learning process. We need to change from traditional modes of teaching to new technological methods. We should go to the digitalization of the teaching-learning process. Develop smart classrooms and laboratories for better delivery of contents. Staff should upgrade themselves to a digital platform. Students nowadays are more techno-savvy, recommending new teaching methods and teaching tools. New techniques are adopted in teaching at Sandip University for effective teaching, considering the recent trends. The use of cell phones, laptops are promoted as teaching-learning tools. Teaching resources are shared with students using Google classroom and other such internet tools. Activity-based Learning (ABL), Project-based Learning (PBL), Case-based learning (CBS) are adopted effectively in teaching. Students are submitting the assignments by copying without understating the concept, which is not deserving. Only exhibiting the reproduced content is of no worth. There should be some learning outcomes from the assignments. The method of submission/assignments is changed. PBL and ABL related tasks are given to the students.

Submission/ assignments should be fun in learning, not a burden or compulsion.

Qualified and well-trained staff recruitment is necessary. Staff should develop a new teaching methodology with modern teaching aids available—recommendation of teacher training programs regularly.

Learning material should be in hard or soft copy, supported by audio-video contents. Students need to teach by giving day-to-day and recent examples of the related topic. Case studies are preferred.

By giving due consideration, the Yoga sessions were regularly organized at Sandip University as a part of the case study. Fig. 6-16 shows students performing Yoga sessions.

Figure 6-16: Yoga practice at Sandip University, Nashik.

6.8. STAFF RESPONSES

Another essential stakeholder of the education sector, like the student, is the staff. The questionnaire floated between engineering teaching faculty members from the same institutes from where student's responses were collected.
The number of staff members and the institute is tabulated below in Table: 6-15.

Table 6-14 Number of responses from staff members

Sr No.	Descipline	SITRC	SIEM	SUN
1	Mechanical Engineering	13	15	8
2	Civil Engineering	8	9	14
3	Computer Science Engineering	22	9	7
4	Electrical Engineering	8	14	6
5	Electronics and Communication Engineering	7	8	
6	IT	10	7	
7	Aerospace			5
	Total : 170	**68**	**62**	**40**

An open-ended questionnaire floated consisting of the following questions:

1. What is your opinion regarding Indian technical education?
2. How to make students industry-ready?

The sample feedback of the faculty members is attached in Appendix C – Staff Responses.

6.8.1. FEEDBACK BY FACULTY MEMBERS

The feedback of the faculty to the questionnaire showed similarity with that of students' feedback in both the questions. Based on this, the sub-criteria identified from the faculty members' points in response to the questionnaire. Faculty feedback highlighted many new issues, which are focused on enhancing the quality of technical education. In the previous chapter, from student feedback, thirteen parameters were shortlisted. Fig 6-17 shows the points from the analysis of faculty.

Staff →

- Academic
- Staff/ Student ratio
- Qualification/ Experience of Faculty
- Faculty retention
- Syllabus coverage
- Communication skill
- Advance Teaching Aid
- Industrial visits/projects
- Practical exposure
- Co-curricular activity/ Cultural activity
- Seminar/workshop
- Research Activities
- Exam/Evaluation
- Employbality

Figure 6-17: Detailed hierarchy of the staff criteria

The criteria mentioned above, as per AHP, are taken as the base for further analysis to formulate the TPE pillars.

CHAPTER 7. MODEL FOR EDUCATION - TPE

TPM and its advantages have been discussed in previous chapters. In this chapter, the TPM definition from industry is mapped to educational institutions. Total Productive Education, as indicated from TPM, would be the educational model (TPE)
Table 5-2 and Table 5-3 show the criteria and sub-criteria defined by AHP, as well as the hierarchy shown in Fig. 5-1. In addition, the criteria/problems are listed, and the frequency of student responses are noted in Table 6-8, and Fig. 6-9 (Pareto Chart), and criteria from staff input are considered in Fig. 6-17. The following are the areas found for improvement by applying the TPM definition as TPE and tabulated in Table 7-1, based on student and staff feedback (attached in Appendices B and C).

Table 7-1: Areas for improvement in the education sector

1	Academics/ Syllabus in line with industry requirements and new trends
2	Industry institute linkage/ Industrial visits/ Seminars/ Workshops / Events/ Value added programs / Co Circular activities/ internships / in plant training/ project work
3	Innovation/ R & D /New Technology/ Technical/ Industry/ Abroad
4	Professional Languages / Soft Skills/ Personality Development
5	Counselling / Psychology/ Human: Mind and Body / Stress/ sports / Fitness Centre/ Discipline
6	Infrastructure - Hostel / canteen/ Books/ Labs/ Internet & Wi-Fi/ smart Class room/ Digital Library/Administrative facilities
7	Time Management / Attendance / Exam Timetable
8	Caste/Cost/ Fees/ Finance / Scholarship
9	Business / Entrepreneur/ Employability
10	Qualified and Experienced staff/ Excellent Teaching Learning
11	Training and Placement of Students
12	Training of Faculty members
13	Industrial exposure to Faculty and students
14	MOU with industry
15	Industry Institute Interaction Cell
16	Financial support from management
17	Exam – pattern/marking scheme/timetable etc.

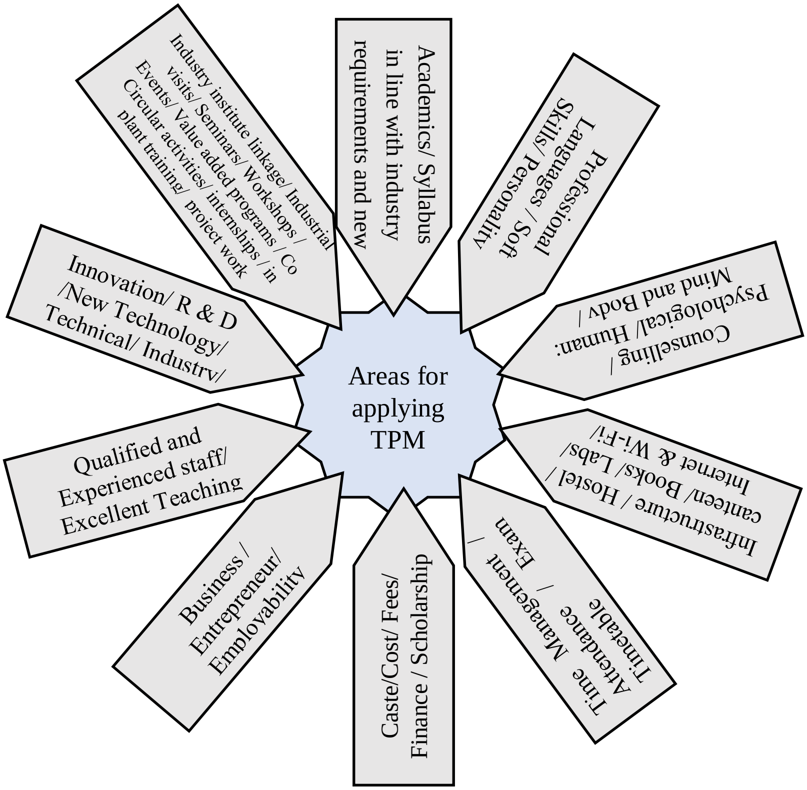

Figure 7-1: Areas for applying TPM in the education sector

The areas where TPM can be used in the education sector are depicted in Figure 7-1. Tables 5-1 to 5-3 and Table 7-1 show the areas found from the AHP literature. It aids in the formulation of the foundations and standards for the education sector as a result of these. A systematic approach was used to find the analogy between industry and institute. The parameters from both are mapped in order to create the education model from the TPM concept.

7.1. PILLARS FOR EDUCATION SYSTEM

The education sector is comparable to the service sector in terms of the industrial OTPM pillar. The other seven pillars work together to assist the OTPM pillar in reducing losses and improving efficiency. If a similar concept is applied to the education sector, the quality of educational institutions will improve. Figure 7-1 depicts the specified areas where TPM can be used in the education sector. Based on it, Table 5-3, Fig. 5-1, and Table 7-1 suggest the following pillars for the TPM-based TPE model in the education sector.

1. Admission
2. Academic
3. Activities
4. Collaboration/MoU
5. Examination
6. Finance
7. Infrastructure
8. Support Systems
9. Training and Placement

The eight pillars of TPM are concerned with reducing/eliminating losses. Similarly, the proposed education pillars would concentrate on eliminating problems in technical institutes. The chapter goes into greater detail about simulating the TPM model for the education sector. TPE is simulated using the simulation/similarities of an education institute to that of an industry and TPM pillars, losses, and requirements - PCQDSM.

7.2. SIMILITUDE ANALYSIS OF TPM – FOR INDUSTRY AND INSTITUTE

TPM is a tool used in industry to increase efficiency by making better use of the equipment and facilities available. TPM is a maintenance program that entails a systematic approach to plant maintenance by controlling equipment and facilities. The characteristics of the organization and process similitude analysis with the industry are performed for the education scenario. In industry, raw materials are transformed to finished products through a specific manufacturing process, while in educational institutes, students at various levels of study are raw materials that are upgraded to higher qualifications via the teaching-learning process. Industry equipment is similar to research facilities, teaching-learning aids, computers, office facilities, and so on from educational institutions. There is a similarity between industry and institute, as seen in Fig. 7-2, when equipment, operation, and resources are considered.

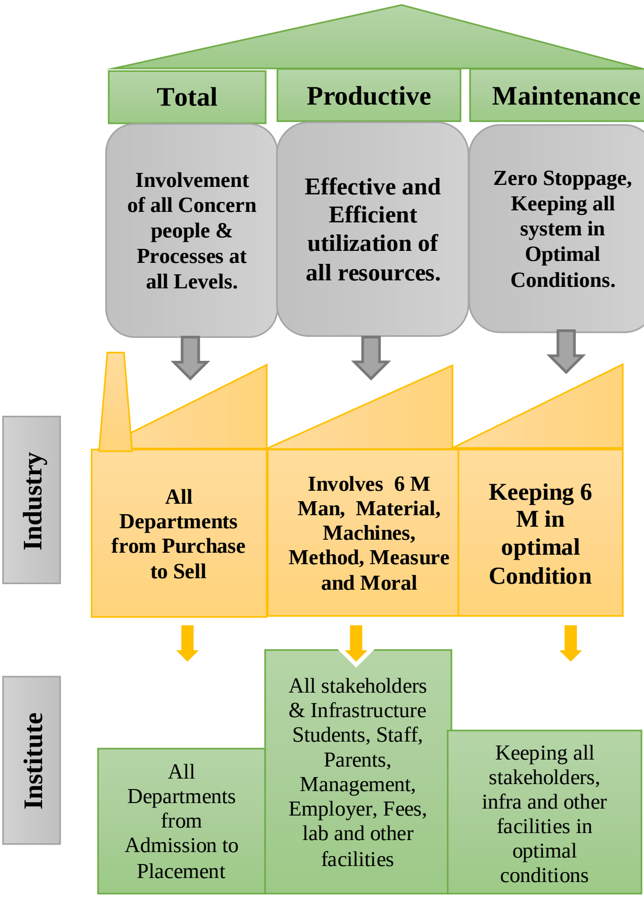

Figure 7-2: Similitude Analysis - TPM in industry and education

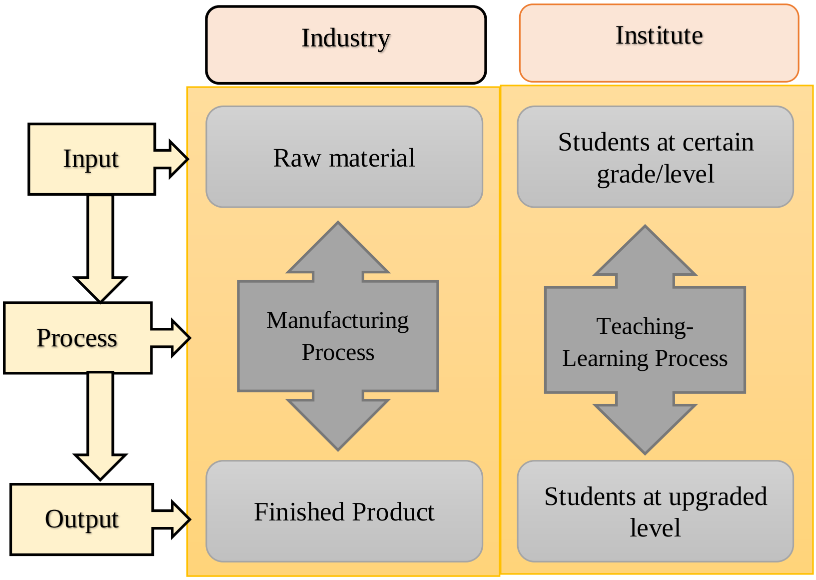

Figure 7-3: Input-output resemblance for industry and institute

Figure 7-3 depicts the similarity in input and output for the industry and institute. The raw material processed by the manufacturing unit and turned into a finished product is referred to as input for the industry. In education institutes, however, students from lower levels are taught and promoted to a higher level through the teaching-learning process.

7.3. SIMILITUDE ANALYSIS – TPM PILLARS FOR INDUSTRY V/S INSTITUTE

TPM is successfully applied in industries to minimize losses. Table 7-2 suggests a similitude study between industry and education for eight TPM pillars in terms of goal, losses, and efforts to reduce/eliminate them.

Table 7-2: Similitude Analysis of TPM pillars for industry and institute

Autonomous Maintenance (JH)	
Industry	**Engineering Education Institute**
Target: To instil in the machine's operator a sense of ownership in order for it to function properly.	**Target:** To give staff, students, and employers more control over curriculum creation and infrastructure use.
Losses: Focuses on reducing performance loss and increasing equipment efficiency.	**Problems:** Maintenance of – Infrastructure laboratory equipment and tools. Outdated syllabus.
Actions: The operator is given complete control of the unit. Training the team to be capable of handling all working conditions and resolving the maintenance issue on their own. It improves employee ability and participation in the workplace.	**Actions:** Students and faculty are in charge of operating and maintaining laboratory equipment. Students' realistic approach improves as a result of their participation. Students, in addition to teachers, should be tasked with the upkeep of lab equipment and materials. It will instil a sense of ownership in the students. Involve students, faculty, and business members in curriculum development and syllabus revision based on recent developments. Employers are end-users because they use the output, i.e., students, as input to the industry. Their recommendations for syllabus design and increasing students' skill set are important for increasing placement.
Individual Improvement (KK)	
Target: Employees from all the departments.	**Target:** Stakeholders - Students, Staff (teaching, non-teaching), and supporting.
Losses: Breakdown Maintenance	**Problems:** Maintenance of laboratory equipment is a skill that students must learn in order to be employable.

Actions: Employees are trained to be capable of addressing problems on their own with the necessary skills.	**Actions:** Faculty and students should be made aware of opportunities to improve their problem-solving skills, self-learning capacity, and involvement in research and development and consulting work. They should be trained to be able to solve laboratory equipment repair problems. Conduct value-added workshops and numerous competitions to help students improve their skills and abilities. Conduct teacher training programs.
Planned Maintenance	
Target: Equipment and Process conditioning. **Losses:** Failures and Defects **Actions:** Increase output by minimizing defects and failures. Increase machine availability by reducing maintenance. Organizing the equipment and setting the processes.	**Target:** Students and faculty up-gradation. **Problems:** Outdated Syllabus – curriculum revision not done frequently. Less exposure to Industries of staff and students. **Actions:** To coordinate co-curricular and extracurricular programmes for students in addition to curricular activities. Internships, projects in collaboration with industries, industrial visits, lectures from industry experts, technical conferences, new advances in industries, and product awareness can all provide students with exposure to the industrial climate. It should assist students and faculty in expanding their knowledge and skillset, thus improving their employability.
Quality Maintenance (QM)	
Target: To prevent and control the occurrence of the defect. **Losses:** Failures and maintenance. **Actions:** Focus on the preventive measure – cause-oriented approach, rather than reactive action –result-oriented approach.	**Target:** Laboratory machines and equipment. **Problems:** Laboratory equipment and tools are not well-maintained, resulting in mistakes and flaws during practicals. **Actions:** Laboratory equipment must be maintained on a regular basis.
Administrative/Office TPM (OTPM)	
Target:	**Target:**

Day to day Administrative functions, logistics, and support system. **Losses:** Failures and maintenance. **Actions:** TPM is used to increase the effectiveness and productivity of administrative functions.	Administrative and support systems, canteen, hostel, transportation, etc. **Problems:** Wastage of time in non-productive work like ques for filling up f forms, payment of fees, waiting for canteen and transport. **Actions:** The admission process to placement, wherever the administrative function is involved, should be hassle-free. Form filling, payments, and bookings to be done online to avoid queues.
Training and Education	
Target: To develop a skilled operator. **Losses:** Avoid labor loss. **Actions:** Training of operators to develop and endure skilled operators by appropriate training methods. Training the operators regarding other TPM pillars. Provide infrastructure for training.	**Target:** Laboratory machines and equipment. **Problems:** Maintenance of laboratory equipment and instruments, which may results in errors and defects during performance. **Actions:** Training the students is the prime objective. Similarly, training of faculties, assistance, trainers, instructors, etc. is also equally important. Students' performance linked to faculty performance.
Safety, Health, And Environment (SHE)	
Target: Zero Accident, Zero Health Damage, and Zero Fire. **Losses:** Accidents, Health issues & Fire losses. **Actions:** Develop a safe and clean workplace and environment. Safety precautions to be taken needs to teach at all pillars.	**Target:** Entire campus. **Problems:** Accidents, Health issues & Fire losses. **Actions:** Training of students, faculties, and other staff regarding awareness of safety, use of safety devices, emergency rescues is a must. Provision of safety equipment, medical kits is to be done. A regular medical check-up required a clean environment is to be maintained.
Initial Control and Maintenance Prevention(IFC)	
Target: Minimizing the life cycle cost of equipment. **Losses:**	**Target:** Entire campus. **Problems:** Accidents, Health issues & Fire losses. **Actions:**

Maintenance and detonation losses **Actions:** While the development of a new product, the design should take care of maintenance, safety, economy, and flexibility, thus reducing maintenance.	To be implemented while developing curriculum, teaching-learning tools (audio, video & training material), smart classrooms, etc. Feedback from all stakeholders regarding improvement in administrative functioning, curriculum, teaching-learning, etc., to be taken regularly.

The analysis in Table 7-2 sets the base for proposing the TPE pillars with targets, problems, and actions required in the education sector.

7.4. COMPARING LOSSES IN INDUSTRY AND INSTITUTE

TPM focuses on reducing industry losses. The 16 major industry losses, as described in section 2.5.1, Table 2.2, are compared, and equivalence is established with the related problems encountered in educational institutions, as shown in Table 7-3.

Table 7-3: Losses in the industry - analogous to issues in the education sector.

16 Major Losses in Industry	**Institute**
1. Setup and Adjustment	➢ Late admission of few students, change in a course/program, change in institute/university
2. Start-Up	➢ Students admitted to a particular course are not having the necessary prerequisite, weak in basic fundamental principles, language problems. ➢ Students are not interested but forced to take admission to a particular program. ➢ Students are failing in exams at the first attempt.
3. Operating Motion	➢ To reduce motion loss, the department's layout should be effective for movement from classroom to laboratories, workshops, seminar halls, canteens, and so on.
4. Line Organization	➢ The dependency of departments - exam department needs timely support from faculties from submission of question bank/question paper to assessment of answer sheets. ➢ Store - to provide Stationary requirements for the department, students printed journals, consumable material for laboratory purposes like chemicals, petrol/diesel.

5. Management	➢ Administrative functioning, delay in the process of admission/ form filling/ banking. ➢ Process for each department: admissions, student section, accounts, exams, departments, training and placement, transport, canteen. ➢ Delay from management in terms of operations and funding, the timely decision in the procurement of workforce, and equipment.
6. Equipment Failures	➢ Inadequate infrastructure to conduct theory classes and insufficient laboratory equipment to perform laboratory work. ➢ Conduction of practicals is affected by the failure of laboratory equipment, machinery breakdown. ➢ Classroom teaching is affected by the failure of teaching aids like LCD projectors, computers, internet. ➢ Transportation affected by bus failure. ➢ Canteen - non-availability of raw material, vegetables, cooking gas. ➢ Office – Failure of ERP, internet, telephone lines, etc.
7. Measurement and Adjustment	➢ Assessment of Staff - Appraisal to be done. ➢ Wrong assessments of students' in examination
8. Minor Stops	➢ Less Attendance of students, Loss of lectures due to non-attainment of staff/student, holidays, strikes.
9. Reduced Speed	➢ Slow delivery of contents by the teacher. ➢ More time is taken for learning and completion of the assignments by slow learners. ➢ The syllabus coverage is not as per the teaching plan.
10. Defect and Rework	➢ Failure of students. ➢ Extra or remedial lectures for the absent or fail students.
11. Scheduled Down Time	➢ Holidays, Preparation leaves, vacations.
12. Yield	➢ Scholarships, discounts are given to students. ➢ Increase in the overhead cost of faculty and infrastructure due to cancellation of admission, non-recovery of fees, fewer admissions than proposed intake.
13. Energy	➢ Losses in energy like electric power, fuel, water, air.
14. Tool Die and Jig	➢ Losses due to laboratory equipment, maintenance, depreciation, replacement of old computers, teaching aids like LCD projectors, smartboards.
15. Cutting Blade (Tool) Change	➢ Laboratory set up for machine equipment to perform practical.
16. Logistics	➢ Material loading unloading at the workshop/laboratory.

7.5. CRITERIA- PCQDSM FOR EDUCATION

TPE pillars are proposed in Section 7.1. Tables 7-4 to 7-12 describe the criteria - PCQDSM to improve the standard of technical institutes for the TPE pillars for these educational pillars.

Table 7-4: Criteria PCQDSM for admission pillar

Admissions	
Criteria	**Parameters**
Productivity	➢ Increase the number of Enrollments ➢ Decrease the number of cancellations and dropouts
Cost	➢ Maintain an affordable fee structure ➢ Decrease the cost of promotional activities
Quality	➢ Improve input quality of students by attracting meritorious students ➢ Increase conversion ratio per counseling done.
Delivery in Time	➢ Timely admission procedure ➢ Handover of receipts and admission kit in time
Safety	➢ Zero Accidental events for faculty on fieldwork for marketing ➢ Ensure the safety of students/parents coming for admission
Moral	➢ The commitment of Motivated staff on the field for the target

Table 7-5: Criteria PCQDSM for academics pillar

Academics	
Criteria	**Parameters**
Productivity	➢ Improve teaching-learning methodology ➢ Improve overall class attendance ratio ➢ Increase staff feedback ratio ➢ Reduce non-productive time during teaching and conducting practicals ➢ Enhance research publications and patents. ➢ Use of ICT based tools
Cost	➢ Reducing Teaching Learning aids (tools) Cost.
Quality	➢ Enhance teaching-learning quality by implementing innovative teaching and assessing methods ➢ Improve in the result of students ➢ Highly Qualified staff
Delivery in Time	➢ Delivering the contents in time by completing the curriculum in time ➢ Performing theory/practicals in time as per the academic calendar
Safety	➢ Ensuring safety while performing practicals in laboratory and workshop
Moral	➢ A commitment of faculty for quality delivery of academics ➢ A commitment of students for attendance of theory and practical sessions

Table 7-6: Criteria PCQDSM for activities pillar

Activities	
Criteria	**Parameters**
Productivity	➢ An increasing number of Industrial visits ➢ An increasing number of expert lectures conducted ➢ Increase the number of events – technical and non-technical for the students for the overall development ➢ Increase the number of projects done by students. ➢ Organizing induction programs for students
Cost	➢ Decrease the cost of visits. ➢ Decrease the cost of events conducted. ➢ Decrease the cost of projects undertaken by students ➢ Increase funds for teaching visits and activities.
Quality	➢ Develop quality projects from activities conducted. ➢ Provide quality training by Experts from industries. ➢ Participation of students in various activities/events organized by professional bodies
Delivery in Time	➢ Conduct visits in time ➢ Conduct events in time ➢ Finish projects and assignments on time
Safety	➢ Zero accidents while conducting visits and events
Moral	➢ Commitment for completion of the visits and activities ➢ To boost the morale of students, awards/prizes in academics/and other activities to be given

Table 7-7: Criteria PCQDSM for collaborations/MoU pillar

Collaborations/MOU	
Criteria	**Parameters**
Productivity	➢ Increase Industry Institute Interaction through cooperation and memorandums of understanding for academic delivery, training, internships, programs, and placement. ➢ Increase MOUs with other Indian and international universities for facilities, student exchange programs, credit transfer, study, and other projects.
Cost	➢ Reduce the cost of the institute for expert lectures, visits with the help of collaboration and MOU.
Quality	➢ Increase Attitude, Skill, and Knowledge of students ➢ Make the student's industry-ready ➢ Increase the quality of research work and publications
Delivery in Time	➢ Timely deliverance of quality education, with additional skills developed in students ➢ Timely completion of projects assigned
Safety	➢ No misunderstanding and reworking of terms and conditions for better performance ➢ Zero cases of breaking the bond
Moral	➢ The commitment of the Institute and Industries for the overall development of students

Table 7-8: Criteria PCQDSM for examination pillar

Examination	
Criteria	**Parameters**
Productivity	➢ Conduction of exam as per academic time table ➢ No rescheduling of theory and practical exams ➢ Effective use of computer for question paper generation, to reduce the number of paper setters involved ➢ Supplementary exam
Cost	➢ Reduce stationery and conduction costs by use of the online process ➢ Reduce paper setting costs by digitalization. ➢ Reduce assessment costs ➢ Reduce costs by conducting an online exam
Quality	➢ Increase overall result passing percentage ➢ Reduce cases of rechecking / reevaluation ➢ Error-free question paper
Delivery in Time	➢ Make exam forms available in time ➢ Provide hall tickets on time ➢ Declare results in time ➢ Schedule a supplementary exam in time
Safety	➢ No panic situations during the conduction of the exam
Moral	➢ Reduce the number of malpractice cases ➢ Proper supervision during the conduction of the exam ➢ Students should follow ethics, no wrong practices

Table 7-9: Criteria PCQDSM for finance pillar

Finance	
Criteria	**Parameters**
Productivity	➢ Increase returns from each department, as per the budget allocated ➢ Increase in enrollments ➢ Increase in Academic results ➢ Increase in Placement ratio ➢ Enhance and motivate digital payments ➢ Timely payments of salaries of staff ➢ Timely payments of suppliers
Cost	➢ Cost for the operation to be properly budgeted ➢ Reduce promotional activity costs by increasing the students/staff recommendations. ➢ Reduce cost on infrastructure by proper use and sharing of resources wherever possible
Quality	➢ Transparency in financial transactions ➢ No rework in receipts and invoices generated.
Delivery in Time	➢ Timely issue of receipts of the transactions ➢ Timely issue of cheques to vendors
Safety	➢ Ensure privacy of account credentials ➢ Safety of documentation in the accounting department
Moral	➢ Follow ethical practice

Table 7-10: Criteria PCQDSM for infrastructure pillar

Infrastructure	
Criteria	**Parameters**
Productivity	➢ Enhancing practical skills in modern laboratories ➢ The modern and advanced approach to learning through e-books and the internet
Cost	➢ To reduce the cost of institute laboratories, recommended setting of laboratories in collaboration with industries. ➢ Maintaining laboratories through expert supporting staff (inhouse)
Quality	➢ Availability of well equipped and advanced laboratory facilities ➢ Advanced computing facilities ➢ Quality books, e-books, and Journals in the library
Delivery in Time	➢ The smart classroom will ensure the delivery of content in time
Safety	➢ Ensuring the safety of staff and students by preventing accidents in well-maintained laboratories
Moral	➢ Ownership feeling of all the faculties towards maintaining infrastructure.

Table 7-11: Criteria PCQDSM for support services pillar

Support Services	
Criteria	**Parameters**
Productivity	➢ Increasing productivity /efficiency of supporting/office staff by providing /arranging training and workshops
Cost	➢ Effective use of ERP to reduce paperwork ➢ Preventive maintenance of the allied systems to reduce break down
Quality	➢ Transparency in daily routine work ➢ Quality of food in the canteen/mess
Delivery in Time	➢ Reducing the waiting time of stakeholders by increasing the number of counters ➢ Providing hostels inside campus thereby reducing transportation time and cost ➢ Providing stores/xerox/utility centers to reduce the time of students
Safety	➢ Ensure security of students and their belongings by implementing security systems such as CCTV, smart gates, biometric, etc. ➢ Providing medical facility inside the campus
Moral	➢ Ethics in work and provide support systems with a subsidized rate

Table 7-12: Criteria PCQDSM for training and placement pillar

Training and Placement	
Criteria	**Parameters**
Productivity	➢ Ensure training to all final and pre-final students to make them ready for industry. ➢ Timely arrangements for training/workshops for staff (teaching and supporting)
Cost	➢ Reduce the cost of training through collaborated agencies. ➢ Organizing/supporting pull campus for placements.
Quality	➢ Enhance the skills of staff and students. ➢ Arrange sessions for stress relief to enhance the quality and productivity of students and staff.
Delivery in Time	➢ Plan for timely completion of training to students before campus interviews. ➢ Without disturbing academics, organize training for staff and students.
Safety	➢ Ensure safety while attending industrial visits, training sessions, and workshops
Moral	➢ Boost ownership feeling of the faculties towards the institute.

7.6. LINKAGE OF TPM AND TPE

Sections 7-2 to 7-5 aim to link TPM used in industry to education through a proposed TPE model. Given the service departments involved, the education sector resembles the OTPM pillar. Section 2.6.1 outlines the OTPM pillar's implementation, including the use of different pillars (JH examples are given). TPE model addresses the proposed transformation of TPM to TPE. TPE pillars are used to implement TPM pillars and tools in the education sector. The losses and criteria defined in sections 7-4 and 7-5 are addressed in the proposed TPE pillars via solutions.

7.7. MODEL FOR EDUCATION SYSTEM

The Total Productive Education (TPE) model is recommended for the educational system similar to the TPM model in the industry. Based on the discussions in chapters 5 and 6, and as proposed in section 7.1, nine pillars are recommended for TPE in the Education sector, with the base being student input quality and the foundation course of pre-requisite knowledge for technical courses.

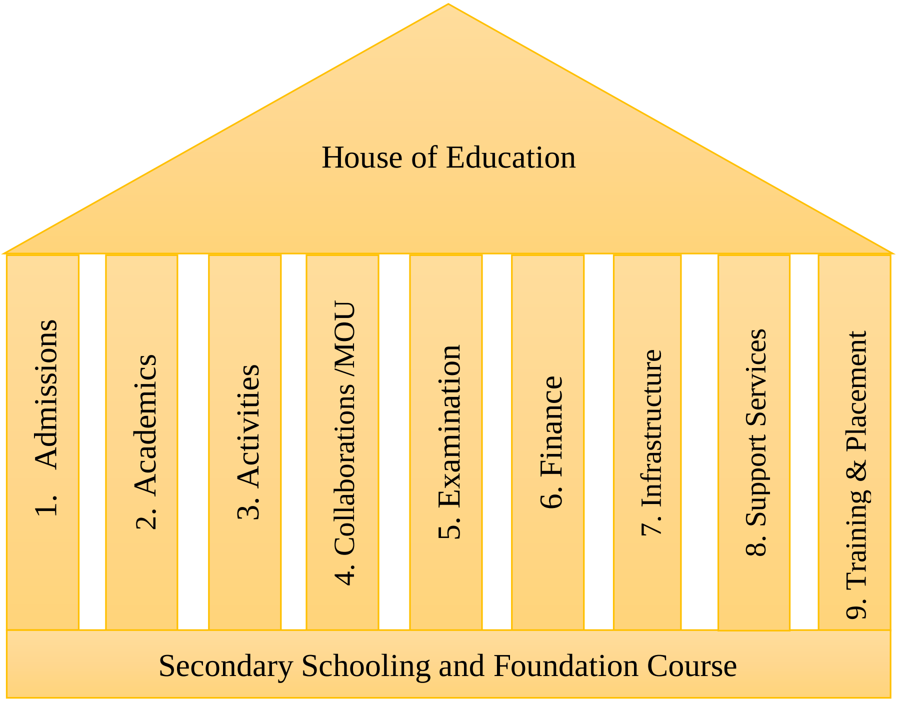

Figure 7-4: Pillars of TPE

7.8. TOTAL PRODUCTIVE EDUCATION (TPE) PILLARS

Figure 7-4 depicts the pillars proposed for incorporating the TPM model in education as TPE.

The foundation of education is student input quality, and the roof is student employability. The performance of TPE is determined by the merit of the students admitted to the technical course. Their fundamental understanding should be strong. Students interested in technical education should be given basic introductory knowledge starting in grade 8 by providing technical subjects. It will improve their abilities. If students lag in fundamentals, a foundation course should be provided before starting technical subjects. As a result, the foundation course is recommended at the beginning of the season. Following the completion of the students' Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis and counselling, the appropriate course should be recommended to them. It will lower the drop-out rate. Students will be taught about the 5-S tool, which will help them maintain proper records and organise their belongings. Minor subjects and skill-based courses should be offered to students in addition to their regular graduation course to help them specialise and develop their skill sets.

TPE pillars are proposed by taking into account the AHP analysis criteria from different stakeholders in the education system – students, staff, society, employer, institute management, employees, and so on. The issues raised by survey responses from staff and students, as addressed in Chapter 5, should be minimised or removed.

Various tools described in Chapter 2 that can be used to reduce/eliminate the identified problems. The primary goal of introducing it is to “Enhance Productivity in Technical Education System.

The outcome of the TPE measured in terms of each pillars output as:

- Placement of the students
- Increase in the enrollment ratio of the students
- Getting good quality students
- Improved results of the students in exam
- Excellent research publication and patents
- Fetching research grants
- Scholarships
- Accreditation and recognition and
- Financial gain to the institutes.

7.9. TPE PILLARS AND TOOLS USED

The TPE pillars, as mentioned above, are listed in detail in this section. For problem-solving, the tools used in the TPM, as defined in chapter 2, section 2.5, Table 2.3, are suggested. Many more tools can be used similarly based on the TPM definition.

7.9.1. ADMISSIONS

Admissions are the first step in the educational process. Admissions determine the university's entire financial status, so admission is proposed as one of the TPE pillars. Students are admitted to different programs at the university/institute based on their qualifications and interests. It is in accordance with the admissions procedures developed by universities and governing bodies.

The motivation for treating admissions as a separate pillar is depicted in Fig. 7-5. Admission is the educational institute's cornerstone. The enrollment of students determines the institute's financial status and credibility.

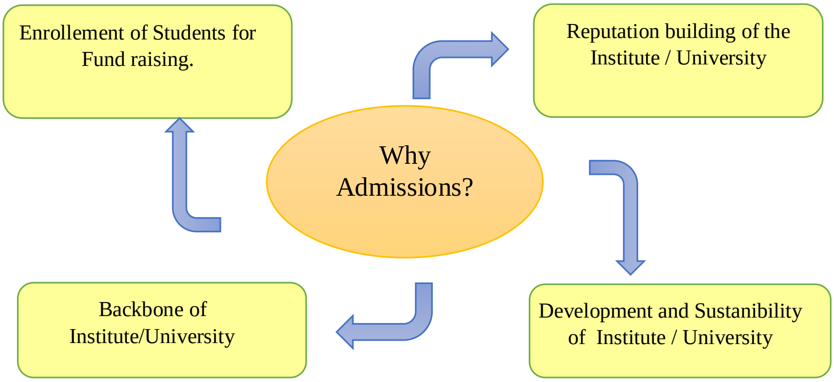

Figure 7-5: Motive of admission pillar

Some of the activities involved under the admission pillar are:

a. **Promotional activities:** It includes the institute's overall branding. Universities participate in a variety of promotional activities to promote their branding or showcase their facilities, such as:
    1. Advertisement
    2. Conducting awareness and career guidance seminars in schools/colleges
    3. Hoardings at various locations.
    4. Audio and video advertisement on radio and television
    5. Newspaper advertisement
    6. Highlight the events, achievements, happenings in university to create awareness in public.
    7. Digital marketing like Facebook, WhatsApp, Instagram, etc
    8. Social Activities to have connections between society and surrounding people.

b. **Entrance Test:** In India, entrance exams are required for professional courses such as engineering, pharmacy, management, and law. The government administers state- and national-level examinations, and students are admitted to their chosen institute based on their merit through a centralized admission process. Many universities hold individual entrance and scholarship tests in order to admit students.

c. **Enrolment Process:** Students may enroll in a specific program based on their interests, either online or offline. As a result, the setup and procedure should be completed. Correctly routed directions and signboards from the entrance of students on campus to the respective department. Counseling, registration of students, verification of documents, completion of forms, payment of fees, issuance of receipts, scanning of documents, issuance of admission package, id card, and allotment of hostel/bus/canteen are all to be completed smoothly.

d. **Admission confirmation:** Admissions are validated by supplying the student with the appropriate confirmation letter/receipt. Students have the option of changing their branch/course or canceling their enrollment. The detailed process, cancellation and refund policies, laws, regulations, and the rules and regulations should be registered and made available. Scholarships and promotions, if any, should be disposed of on time.

TPM Tools used in TPE for Admission pillars can be identified in Table 7- 13:

Table 7-13: Tools used for admission pillar

Sr No	TPM Tool	TPE - Application in the Admission process
1	**5Why's/5W+2H Cause and Effect Diagram**	• Examine the reasons for a decrease or rise in admissions to a specific course/program. • Analyze the cause of a student's late admission or a change in course/change in the institute to complete it on time, or offer a solution such as a foundation course or remedial lectures if admission is late.
2	**Frequency study**	• It is performed by monitoring the promotional activities and collecting data.
3	**Horizontal expansion**	• The tool used to connect new potential areas, resulting in an increase in the number of outlets. • Increase the number of programs in response to demand.
4	**SPC**	• Analysis of enrollment • Conduction and analysis of the exam
5	**The flow chart**	• show the entire process of admission
6	**Check sheet**	• list of documents and process to be followed
7	**Gemba**	• It recommends spot visits at working place to identify the problems in the process and offer a solution. As for the admission process, the set time is supposed 30 minutes, to monitor it and find the problems.
8	**Bottleneck**	• Identify constraints in the process like queues in accounts or students section, the problem in form filling, availability of facilities like photocopy, internet, digital payment modes, etc., affecting timely completion of the process.

9	**Benchmarking**	• Set the target for enrollment by benchmarking some ideal institutes. Adopt best practices followed by them.
10	**Brainstorming**	• It is generating ideas for the marketing and promotion of the university. • Proper focus and funds can be made available to that source accordingly
11 12	**Pareto chart, Scatter diagram**	• Get the proper idea of which activity created maximum leads for admissions, as per last year's data
13	**SOP**	• SOP - set process of documentation for admissions, rules, regulations, admission policies, cancellations, scholarships, etc. • Administrative functioning, delay in the process of admission/ form filling/ banking • The SOP will have the entire process for various departments involved, like counseling, admissions, accounts, student section, libraries, etc.
14	**FMEA**	• Analyze the enrollment of the previous year and identify the failures to achieve targets • Analyze the effect and provide the solution for the next cycle
15	**Kaizen**	• Implement Kaizen at every possible level. It helps to improve the efficacy of the team and the number of enrollments • Kaizen to be done for improvement of the entire admission process
16	**PDCA**	• Applied for continuous improvement in admission procedures and enrollment at all levels
17	**Smart Goals**	• To set and achieve enrollment targets
18	**Histogram**	• To segregate the data as per potential regions of admission • To segregate the data of calls coming in a call center to check the interest of the students and identify the potential areas and courses

7.9.2. ACADEMICS

Academics are the educational system's heart and soul. According to survey results, academics are a significant concern. The survey responses from students and faculty members offered a lot of information. Many academic issues are raised and debated by students and faculty. For academics, there is a maximum number of responses. By

accepting this feedback into account, the areas found are curriculum design, the teaching-learning process, and industrial requirements from students.
In comparison to TPM in industry, input to the education system is students at the secondary school level. Through the teaching-learning process, they are shaped into finished products. And the result is UG/PG students with the required skill sets. Figure 7-6 depicts the motivation for considering academics as a pillar.

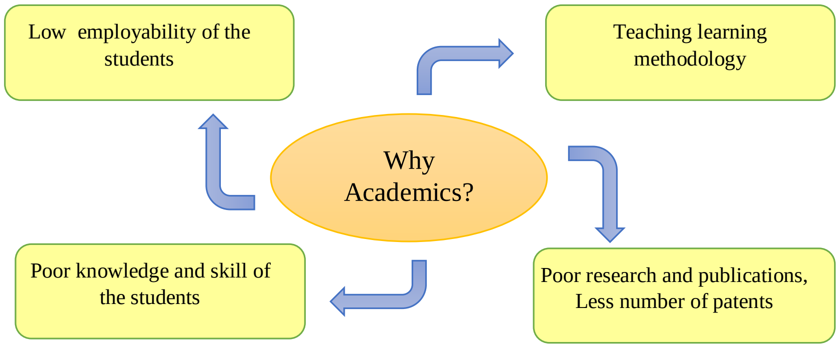

Figure 7-6: Motive of the academic pillar

The institute's placement and research track record contribute to increased student enrollment, which is governed by the institute's teaching-learning approach. Higher student merit would improve placement, and research practices, which academics should oversee. The various factors considered in academics are:

a. **Syllabus / Curriculum**:
The curriculum design determines the outcome of the learning process. It is recommended that the program be outcome-based and relevant, versatile, and capable of meeting the needs of the industry and the needs of society as a whole. The syllabus structure should account for theoretical and practical experience, with appropriate credit given. The assessment scheme must be up to date..

b. Theoretical/Practical Knowledge/Project work/Skills/PBL:
According to the student study results, there is a high demand for practical/laboratory-oriented learning. Enhance your knowledge and skills, and you will develop a positive attitude. Project-based learning, activity-based learning, and skill development programs/workshops can also help to improve teaching-learning methodology. Industrial ventures and internships are recommended for project-based learning.

c. Teaching Learning process/ Staff /Submission/ Digitalization/ Assignments / Learning material / Attendance:

The teaching-learning process should be thoroughly explained and evaluated. It is proposed that approaches based on ICT be used. Recruit experienced and well-trained staff. Establish a proper submission/assignment schedule and process. Assignments can become more hands-on and activity-based. Students should have access to learning materials that are both appropriate and essential. Digital resources, such as Google Classroom and Moodle, can be used. Measures must be taken to pique students' interest in learning so that they attend class eagerly rather than reluctantly.

The following TPM tools are used to enhance the academic performance of the institute. Table 7-14 gives the details:

Table 7-14: Tools used for academic pillar

Sr No	**TPM Tool**	**TPE - Application in Academic process**
1	**Benchmarking**	• To increase overall student performance, refer to best practices from successful organizations.
2	**Brainstorming**	• For curriculum design involving expertise with diverse experience from academics and industry. • Develop effective teaching methodology.
3 4	**Check Sheets** **Control Charts**	• For academic monitoring. • For monitoring the progress of students • For tracking the performance of teaching staff
5.	**Gemba**	• Visit a workshop and laboratory to identify problems for conduction. • Visit classrooms/ laboratories to observe the theory and practical delivery.
6.	**AQL**	• Used to judge the performance of staff based on the number of classes engaged, feedback from students, analysis of the result • Assessment of Staff - Appraisal to be done
7	**Kaizen**	• Do Kaizens for continuous improvement in the teaching-learning process. E.g., upgrading the teaching aids with ICT.
8	**Preventive Maintenance**	• Take measures to avoid failure of teaching aids like LCD projectors, computers, internet affecting classroom teaching.
9	**CUDBAS**	• Curriculum Development Based on Vocational Ability Structure

A few academic problems linked to industry losses as shown in Table 2-2 can be solved as follows.

1. Late admission of a few students, changes in the course/program, shift in institute/university – Solve by holding additional/remedial lectures/classes.
2. Students admitted to a specific course lack the required prerequisites, are lacking in basic fundamental values, and have language issues – Conduct a foundation course to bridge the gap. Organize additional instruction, value-added classes, and personality development programs to help students improve their language skills. Less Attendance of students – create interest in the subject by improving the teaching-learning process, add more practical and hands-on training, and industrial visits to attend the classes with interest.
3. Lectures are lost due to staff/student non-attainment, vacations, and strikes. The teacher's delivery of content is slow. Students that are slow learners, as measured by the amount of time it takes to complete assignments The syllabus coverage does not correspond to the teaching schedule. – Run remedial and extra courses to address all of these issues.
4. Loss as a result of admission cancellation and non-recovery of fees- Admission can be canceled for a variety of reasons. Poor academic performance is a major reason for the cancellation. Academics should be improved, and skill-based training should be provided. Support services such as the canteen, hostel, housekeeping, and transportation should be reliable.

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7.9.3. ACTIVITIES

The Pareto table, as shown in Fig. 6-9, demonstrates that, after academics, activities play an important role in the responses counted from the students and faculty survey mentioned earlier.

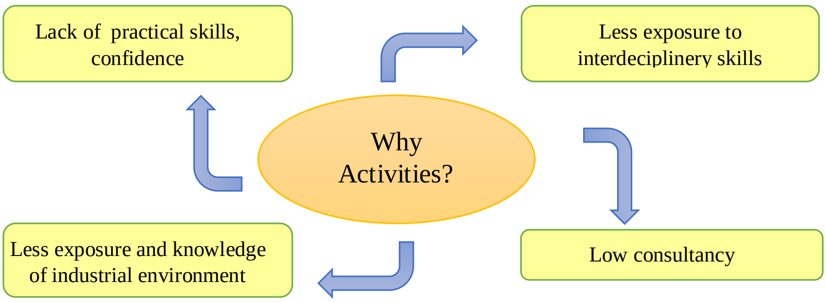

Figure 7-7: Motive of activities pillar

Figure 7-7 depicts the significance of activities as a pillar. To enhance student admissions/enrollment and placement, skill-based, multi-tasking technocrats are needed. Activities are crucial in bridging the gap. It enhances students' skill set, instils leadership habits, fosters communication skills, fosters a study orientation, and so on. It enables students and teachers to provide consulting services as a result of their research and projects.The types of activities considered are as follows:

a. Innovation/ R & D /New Technology

Co-curricular programs provide additional inputs in addition to the program. A cell for innovation and incubation has been developed to improve research activities. Expert talks, industrial visits, projects, and consultancy are used to educate students on current industry developments.

b. Industrial visits/Seminars/WS/ Events/Co Circular activities/ Industry / Abroad:

Paper presentations, conferences, lectures, seminars, and expert talks are examples of technical events that can be planned. Industrial tours and activities will be designed to expose students to new experiences. Boost student knowledge of the expectations of international universities. Foreign students should be drawn as well.

c. Counselling / Psychological/ Human: Mind and Body / Stress / Sports/ Time Management:

The title refers to the issues raised by the students about stress and depression. Academics and exams burden students. To help students solve stress-related issues, Sandip University offers counseling and organizes cultural activities. Students' participation in sports activities is increased. They are inspired to practice yoga in order to revitalize their mind and body. Students are encouraged to prioritize academics, curricular and co-curricular events, athletics, and meditation. To avoid interfering with academics, the activity schedule is carefully organized and presented. Proper counseling is required for students who are not interested but are pressured to enroll in a specific program. Either interest is created or a recommended to change the program/course.

d. Professional Languages / Soft Skills:

Soft skills and foreign language skills are critical for students' overall growth. All are practised at Sandip University, with noticeable changes in the performance.

In addition to the suggestions made above, the TPM tool can be used as shown in Table 7-15:

Table 7-15: Tools used for activity pillar

Sr No	TPM Tool	TPE - Application in Activity pillar
1	**Brainstorming**	• For activity planning
3	**ECRS**	• E – to eliminate repetitive activities. • C – if elimination is not possible, Combine the activities. Inter-departmental activities can be combined.

		• R – if the combination is not possible, reduce the activities. • S – simplify the activities.
4	**Flow Chart**	• Flow can be prepared for each activity, specifying the importance & impact of the activity.
5	**Kaizen**	• Based on previous experience, Kaizens are done for betterment and improvements in the activity

7.9.4. COLLABORATIONS / MOU

Collaboration with various universities and industries accelerates the improvement of students' quality technical education and placement.

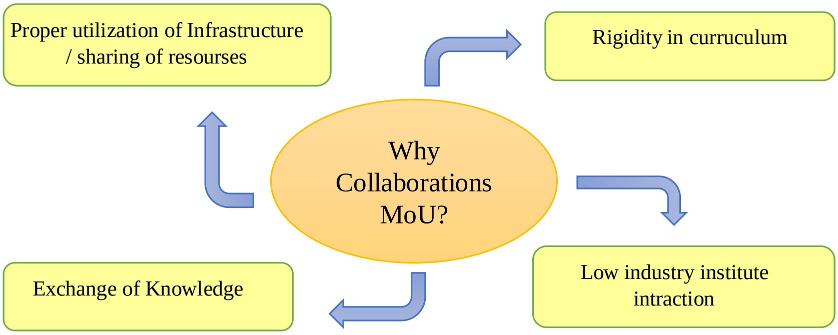

Figure 7-8: Motive of collaboration / MoU pillar

The goal of the collaboration / Memorandum of Understanding is depicted in Fig. 7-8. Collaboration/MoU, in addition to the activities outlined in the preceding section, helps to improve admissions and placements. It can address curriculum shortcomings by information sharing through MoUs with universities and industries. Appropriate use of resources made available by partnerships.

The collaboration/MOU expected with:

a. International Universities:
Collaborations/MOUs are established with international universities to enhance research and development activities through staff-student exchange programmes. To make the most of the facilities by sharing resources. The credit transfer system is made available so that students can gain more global exposure.

b. Industries:
Collaboration with industries aids in obtaining industry experts to educate students, develop curriculum, and provide internships to students. Students and

faculty will take on projects from industries as part of their consulting work. Students can benefit from industrial visits and training..

c. Funding Agencies:

Many government and non-government organisations provide research grants to institutes and universities. These must be authorised and used to solve problems and raise funds. Such agencies/organizations provide seed funding to start-up funds..

d. Knowledge partners:

Specialized organizations/firms may be affiliated as knowledge partners, aiding in the development and operation of university courses. Many enterprises are joining the education sector as part of their Corporate Social Responsibility (CSR) efforts. Their knowledge and experience can be put to good use in designing the curriculum and running the program.

e. Aluminia associations:

Students who have graduated from institutes/universities and have progressed to higher positions or become entrepreneurs will always support the institute's development.

Table 7-16 shows the tools used for collaboration.

Table 7-16: Tools used for collaborations /MoU pillar

Sr No	TPM Tool	TPE - Application in Academic process
1	**Brainstorming**	• Identifying industries/agencies and universities in which to partner
2	**Kaizen**	• Kaizens are done for continuously updating, improving, and expanding collaborations/MoU for increased productivity.

7.9.5. EXAMINATION

An examination is a method for assessing and evaluating students' knowledge and skills. The examination is one of the most important departments, and the institute/university's progress depends on the exam section's success. Fig. 7-9 depicts the intention of concentrating on analysis as a pillar. The method in which the test is conducted has a significant impact on the results. Inadequate conduct and evaluation could result in a higher dropout rate, resulting in a negative reputation for the University.

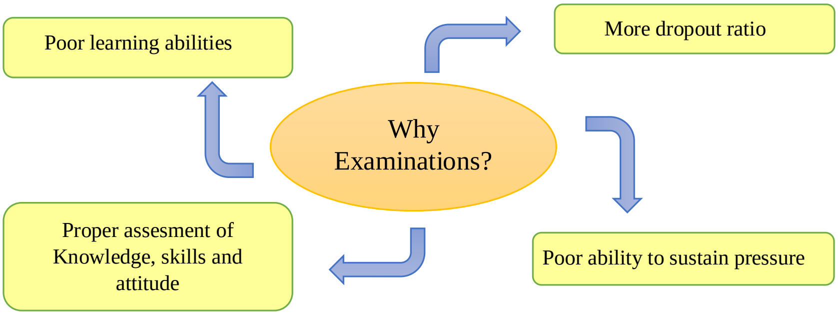

Figure 7-9: Motive of examination pillar

One of the most important pillars to consider is an examination; the factors are shown in Fig. 7-9. It grades students based on their ability and a reflection of the knowledge gained. The exam allows you to assess a student's abilities, expertise, and capacity. We may categorise students as fast, medium, or slow learners and take appropriate corrective action, lowering dropout rates and increasing employability.

The points discussed in this section are:

a. **Exam Pattern:**
Exams may be administered in a variety of ways. According to student feedback, more emphasis should be placed on practical-based evaluation. Continuous internal assessment relieves students of overload at the end of the semester/year.

b. **Assessment /Marking scheme:**
The marking scheme described in the curriculum structure has an impact on the teaching-learning methodology. Theory and practicals should be thoroughly evaluated. Continuous assessment can take the form of assignments, exams, practicals, presentations, and so on. End-of-semester exams will be administered in all three types – verbal, written, and practical/laboratory-based, depending on the subject's requirements.
Students' evaluations should be regularly tracked, and plans for raising their level to a higher level should be put in place..

c. **Supplementary Exam:**
The supplementary exam is provided to students who did not pass their subjects at the end of the semester. It is taken one month after the results are declared. This allows students to complete the subject by not having to wait for the next semester's test. Students who fail their exams on the first try – a supplementary test is an opportunity to enhance their results.

d. Result Declaration:

A timely declaration of results is needed for preparation for the next exercise. Students who perform poorly will be given extra time for the supplementary test.

Table 7-17 shows the application of tools in the examination process.

Table 7-17: Tools used for examination pillar.

Sr No	TPM Tool	TPE - Application in the Examination process
1	**Kaizen**	• Promote Kaizens for continuous improvement in the examination process.
2	**2- Bin System**	• Properly maintain inventory required for the examination.
3	**Poka Yoke**	• Set up an error-free process.
4.	**SOP**	• The dependency of departments - exam department needs timely support from faculties from submission of question bank/question paper to assessment of answer sheets.

7.9.6. FINANCE

One of the suggested pillars in TPE is finance. It will focus on the financial aspects of the Governance/Management who have invested in the university/institute. The second aspect of finance is concerned with students – tuition, grants, free ships, and so on. The finance pillar is proposed from two perspectives: finance required by the organisation to establish and run the institute, and finance from the student's point of view. A student is an input for an institute/university; students' financial situation should be considered a significant part of this pillar.
The justification for treating finance as a separate pillar is depicted in Figure 7-10.

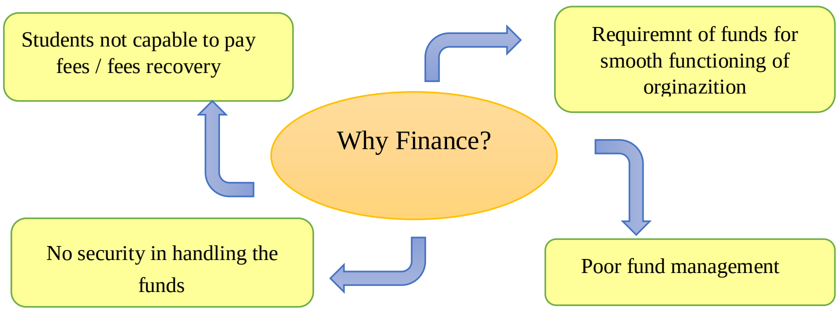

Figure 7-10: Motive of finance pillar

Finance, as depicted in Fig. 7-10, is concerned with the organization's fund management. Budgeting is important for the show to run smoothly. The finance pillar's job is to keep track of credit and debit. The following points pertain to the finance pillar.:

a. **Management Perspective:**
Management provide funds for infrastructure construction and maintenance, R&D, and other operations.
All of the other pillars depend on the Finance pillar, which is a donor pillar. Management is entirely responsible for the success of this pillar—provisions needed in accordance with the budget raised by other pillars. Finance assistance is needed to operate the organization.
Aside from management investing the funds, the source for raising funds is gradually established in the institute/university, such as student fees, event organization, consultancy, and so on, from other pillars as defined in the pillars.

b. **Student Perspective**:
Students pay fees, on which the organization's entire operating capital is based. The number of students enrolled and the fee structure are important factors in the institute's long-term viability. Scholarships are being offered in order to increase enrollment and attract meritorious applicants. Seats will be set aside for scholarships because they have a significant impact on revenue generation..

Table 7-18 shows the TPM tools recommended for the Finance pillar:

Table 7-18: Tools used for finance pillar

Sr No	TPM Tool	TPE - Application in Finance pillar
1	**Poka Yoke**	5. Set up an error-free process.

7.9.7. INFRASTRUCTURE

The infrastructure pillar is concerned with the essential provision of a location, infrastructure, facilities, and support for the establishment of any organization. The company makes a one-time investment in land and buildings as infrastructure. It is the starting point for other stuff. Infrastructure is essential in the early stages of establishing the institute's credibility. Return on investment requires the provision of necessary and optimized infrastructure. The explanations are depicted in Figs. 7-11.

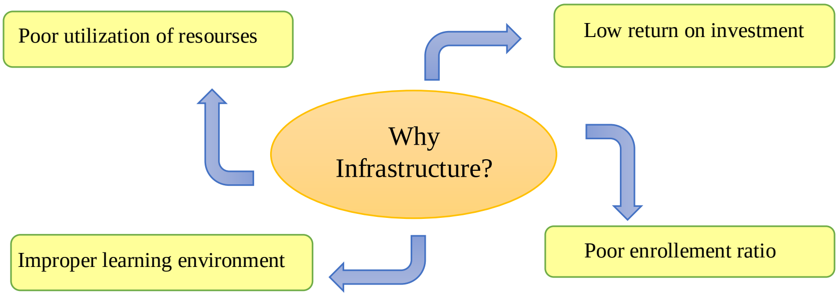

Figure 7-11: Motive of infrastructure pillar

The infrastructure is the most basic necessity for establishing a company. Before the company may begin operations, a few basic requirements must be met. As shown in Fig. 7-11, if the infrastructure is inadequate, the learning environment will suffer. In terms of enrollment, this has an effect. The finance pillar would suffer if enrollment is low and infrastructure is not properly used. It is a loop that is dependent on each other, so this is also an essential pillar.

This pillar outlines the basic infrastructure requirements for the university/institute. Infrastructure pillar considers the following points::

a. **Land and Buildings:**
These are the preliminary criteria for establishing the organization. The organization's development would be influenced by the organization's location and land area. Buildings needed for the establishment of classrooms, laboratories, hostels, canteens, and so on are built first, and then the expansion will be an ongoing process as and when required.

b. **Laboratories:**
Well-equipped laboratories with enough space for experimental setup and room for expansion are needed. Students would be drawn in by high-tech equipment.

c. **Library /Books:**
One of the criteria for technical institutes is a library with an appropriate number of books. The modern library must include journals, magazines, proceedings, and e-books. An e-library with internet access is needed.

d. **Smart classroom:**
The smart classroom is a requirement for today's education. Internet access, projectors, and other amenities are needed in the classroom. According to the specifications, online lectures are delivered in a classroom environment. Smart classrooms can be used for ICT-based digitalized learning.

e. Hostel:
On campus, a hostel with all of the necessary amenities is needed. Separate hostel facilities for girls and boys, as well as staff quarters on campus, draw more students.

f. Canteen:
For the students, a hygienic canteen with enough space is required. Canteen facilities that take into account different food requirements of students based on their native place and community, if accessible on campus, are an added bonus to hostel students.

g. Playground:
Playgrounds, gyms, indoor and outdoor sports are additional points of interest and necessities for students.

h. Other Amenities:
Some of the additional facilities considered in infrastructure are auditoriums, meeting rooms, lecture halls, parks, service centres, parking areas, prayer rooms, and so on. It can be added at a later date.

Table 7-19 lists the tools recommended for the infrastructure pillar:

Table 7-19: Tools used for infrastructure pillar

Sr No	TPM Tool	TPE - Application in Infrastructure
1	**5-S**	• 5-S system for cleaning, organizing, and maintaining a work area – classroom, library, laboratories, workshop, etc. to maximize efficiency and consistency.
1	**Kaizen**	• Promote Kaizens for continuous improvement in maintaining and effective utilization of infrastructure. • The implementation of Kaizen can reduce losses in energy like electric power, fuel, water, air
2	**CLIT**	• Maintenance of laboratory and workshop equipment. • Laboratory equipment, machinery breakdown/failure, which affects practical conduction • Reduce set up a time for a machine, equipment to perform practical.
3	**Visual Cues / Painted Floor**	• Marking off the work areas, direction signboards, parking spaces, campus layout, etc.

4	**Preventive maintenance**	• Losses due to laboratory equipment, its maintenance, depreciation, replacement of old computers, teaching aids like LCD projectors, smartboards.

The department's architecture should allow for movement from classroom to laboratories, workshop, seminar space, and canteen – Infrastructure should be made available when taking into account all potential movements and constraints. Management should include the necessary facilities to conduct theory classes as well as appropriate laboratory equipment to conduct laboratory work.

7.9.8. SUPPORT SERVICES

Like office TPM – OTPM pillar of industrial TPM, support services are considered in this pillar for an educational model of TPE.
This pillar would take into account all supporting agencies, including safety and the environment. Proper support systems will benefit from the organization's credibility. It boosts the effectiveness of the other pillars. The support structure ensures the organization's fitness and hygiene. It also offers a friendly working environment.

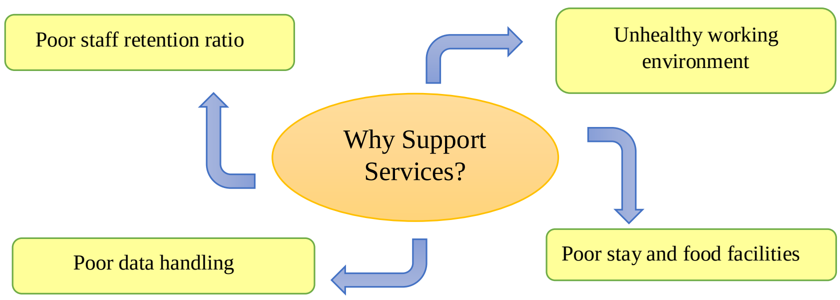

Figure 7-12: Motive of Support service pillar
Figure 7-12 depicts the rationale for recognising support services as a pillar. The educational organisation is a business that provides a service. In this industry, providing excellent service is critical to attracting students as customers. All of the facilities listed below must be properly managed and run.

a. Administration Office: For carrying routine activities right from administrative to academics. A well-qualified and trained workforce is needed.
b. Hostel: Supporting staff for maintenance, monitoring, security, and safety required. Facilities for drinking water, solar system, lighting, and others are required.
c. Transport: Supporting staff – Trained drivers, attendants, and staff for maintenance required.
d. Canteen: Trained cook and supporting staff required—provision for disposing of waste needed.

e. Housekeeping: Cleaning and maintenance of the campus.
f. Security: Sufficient guards and security persons, monitoring systems like CCTV needed.
g. Stores / Xerox/ Utility: other facilities required by students and staff on campus like provision and stationery store, reprographics center, and other utility centers required.

Tools suggested for solving the problems are tabulated below in Table 7-20.

Table 7-20: Tools used for support system pillar

Sr No	TPM Tool	TPE - Application in Support System
1	**5-S**	• 5-S system for cleaning, organizing, and maintaining a work area – canteen, hostel, campus, garden, playgrounds. Etc.
1	**Kaizen**	• Promote Kaizens for continuous improvement in support services.
2	**2- Bin System**	• Properly maintain inventory required in a central store, canteen, hostel, and transport. • Provide Stationary requirements for the department; students printed journals, consumable material for laboratory purposes like chemicals, petrol/diesel.
3	**Poka Yoke**	• Set up an error-free process.
4	**PDCA**	• Enhance the efficiency of the support systems by implementing PDCA for continuous improvement.
5	**Preventive Maintenance**	• Transportation - Bus failure. • Canteen – non-availability of raw material, vegetables, cooking gas. • Office – Failure of ERP, internet, telephone lines, etc.
6	**Standardized work**	• Documentation of Procedures followed by various departments.
7	**SOP**	• Process setup for each department admissions, student section, accounts, exams, departments, training and placement, transport, and canteen for smooth functioning.

7.9.9. TRAINING AND PLACEMENT

Placement demonstrates the organization's efficiency. The number of students placed represents the educational system's outcome. Training improves the skills of students, faculty, and all supporting faculty on campus. Training and placement are inextricably linked.

The points elaborated are:

a. Students training as per the requirement of industries
b. Faculty training and industrial awareness
c. Training of supporting and Non-teaching staff

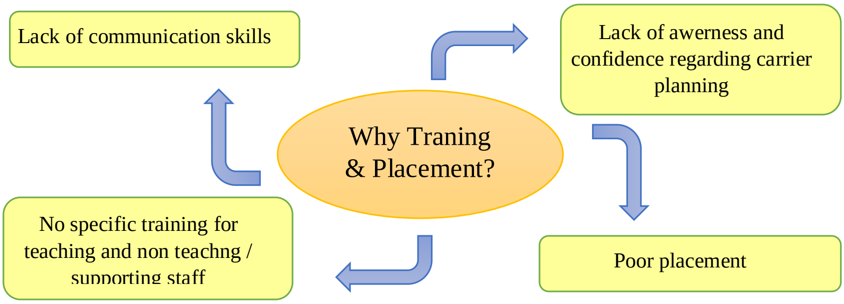

Figure 7-13: Motive of Training and Placement pillar

The motive of considering Training and placement as the pillar is elaborated in Fig. 7-13. The training and placement pillar is for all the stakeholders, students, faculties, and industry. It is like finishing school for the students, improving their communication skills and ready-to-face interviews. This improves the employability of the students. It trains the trainers/teachers to upgrade their knowledge.

TPM tools suggested for Traning and placement are as per Table 7-21:

Table 7-21: Tools used for training and placement pillar.

Sr No	TPM Tool	TPE - Application in Training and Placement
1	**5 Why's / 5W+2H**	• It is implemented for improving placements
2	**AQL**	• Improve the quality of students to make them employable
3	**Benchmarking**	• Goals for maximum placements with handsome packages.
4	**Brainstorming**	• Brainstorming sessions focusing on the increase in the number of placements.
2	**Frequency Study**	• Identify different tiers/levels of companies.

		• Collecting data of students as per their academic record, interest, and map them with requirements of industries.
3	**Histogram**	• To segregate the data of students and industries.
4	**Cross-Training**	• Providing students multi-skills. • Preparing staff for multi-tasking

7.10. LINKAGE OF PILLAR WITH OTHER PILLARS

The above subject includes a comprehensive overview of the TPE pillars. The discussion focuses on the pillar's function, the problems identified as contributing to these pillars, and the expected outcome of implementing the TPM pillars. The successful use of the TPM tool would aid in the reduction of the problem and the improvement of educational quality. Individual descriptions of the suggested pillars are given in section 7.8. The contribution of other pillars to the individual pillar, on the other hand, is equally important. Other pillars can contribute to enhance the parameters of the chosen pillar. The functioning of the pillars is interconnected/dependent on one another. The connection between these pillars is discussed in this section.
This is accomplished by describing the Pairwise contribution of pillars to others, as well as the linkage, in this section from Fig. 7-14 to 7-22. One pillar is positioned in the centre, and the contributions of others to that pillar are noted, forming a connection between them. It depicts how the pillar can contribute to the central pillar, making pairwise comparisons of the pillars easier. This aids in determining the possible area of the pillar in relation to one another. Mutual interdependence and promotion of the other pillars would significantly improve technical education's overall efficiency and productivity..

7.10.1. LINKAGE OF ADMISSION PILLAR WITH OTHERS

Figure 7.14 depicts the admission pillar's relationship to the other eight pillars. Admissions are the most significant factor in the growth of any institute. The merit of the students admitted to any institute determines society's confidence in that institute. Institute strives to attract good quality (students with higher merit) students. To increase admissions, the contribution from other pillars is required as discussed below.

- For effective admissions, the institute should have a high-quality teaching-learning process with an up-to-date and advanced curriculum that results in professional performance. The institute should implement a new approach, such as OBE. This is the academic pillar's contribution.
- Admissions are influenced by highly qualified and experienced faculty members, good infrastructure, advanced labs, a good hostel, and canteen facilities. In the support pillar, good transportation and health care services are equally essential for attracting admissions.

- Students are involved in the quality and quantity of curricular and co-curricular activities in addition to academics. Hands-on training, industrial visits, and internships are needed for practical exposure. Along with these sports facilities are also important in Activities pillar.
- Collaborations with industries and academic institutes play an important role in the industry-institute interactions.
- Examination systems do contribute to the admissions, while training and placement directly attract meritorious students. The affordable fee structure and scholarships on a merit basis attract the students.

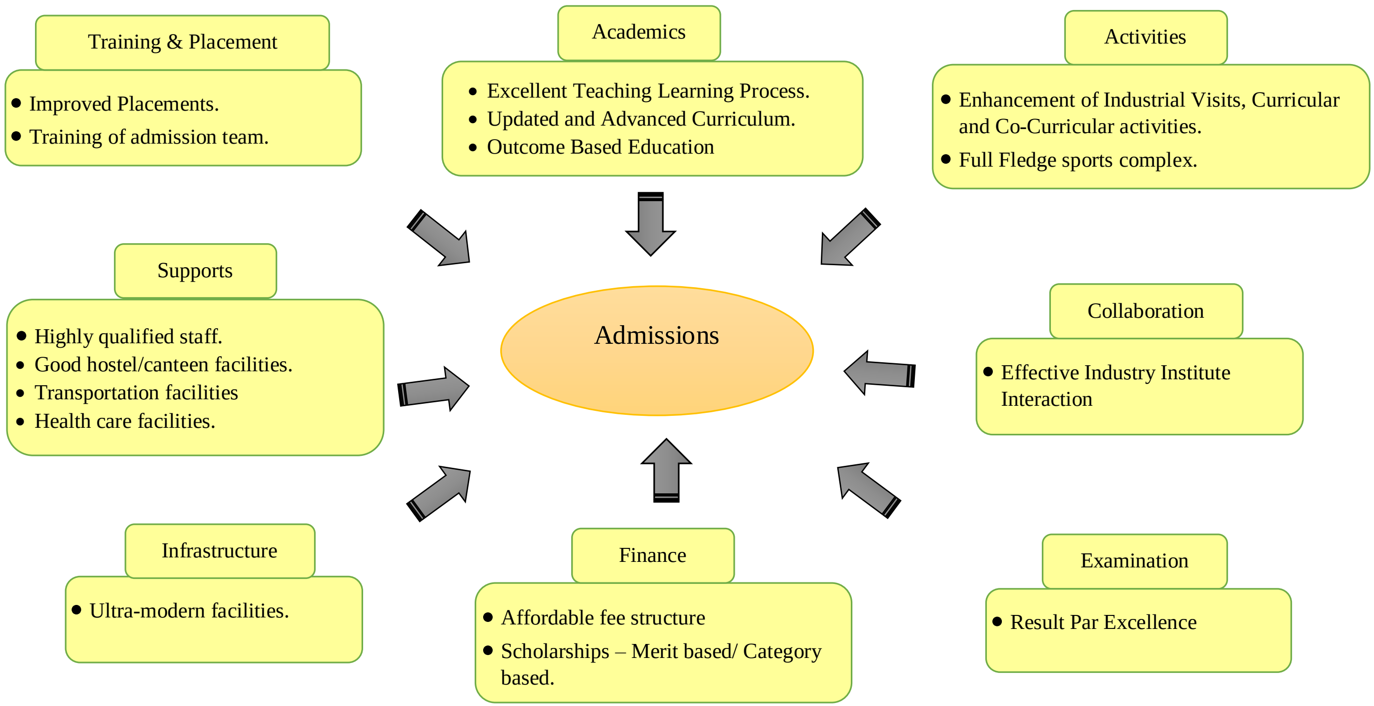

Figure 7-14: Linkage of admission pillar concerning others.

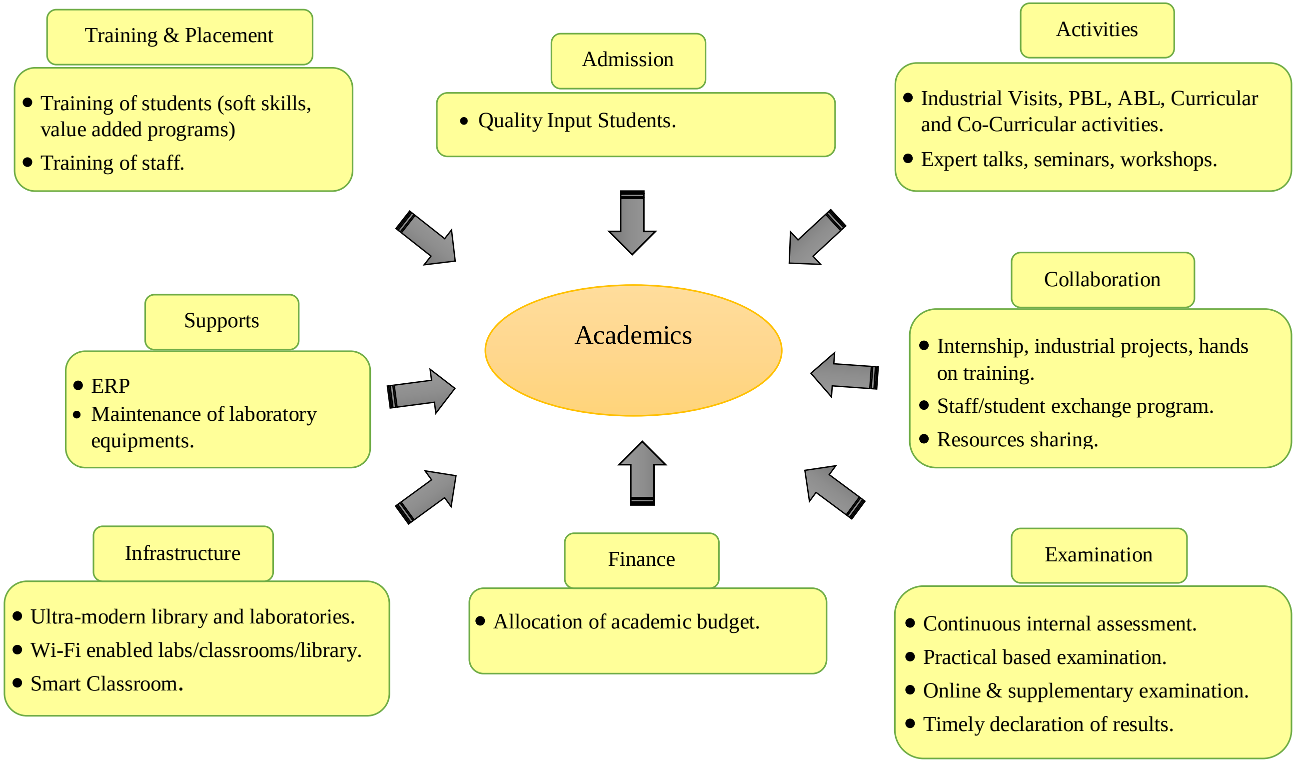

Figure 7-15: Linkage of academics pillar concerning others

7.10.2. LINKAGE OF ACADEMICS PILLAR WITH OTHERS

Fig.7.15 shows the Linkage of academic pillars concerning other pillars. Academics are the heart of any higher technical education institute. The quality of academics decides the faith of any institute. All pillars contribute directly or indirectly towards the achievement of the goals set up for improving academics.

- The admissions pillar contributes by accepting deserving candidates.
- Activities such as expert talks, seminars, and so on contribute to the student's development and understanding. Project-based learning and industrial visits help students develop their practical skills. This contributes to improved academic quality.
- Collaborating with companies aids in academic goals by working on good initiatives and completing an internship for hands-on experience.
- Exams are a measure of what students learn academically. Theory and practical examinations may be used to assess skills.
- High-quality facilities, such as cutting-edge laboratories, classrooms, libraries, and internet access, leads to academic success.
- The training department contributes to academia by supplying staff and students with training. Soft skills and value-added activities may be organized to help staff and students improve their skill set also, for the support staff to use the ERP and develop their computer program skills.
- To prevent failures, the support department manages the routine maintenance of labs, classrooms, ERP, and other systems..

7.10.3. LINKAGE OF ACTIVITIES PILLAR WITH OTHERS

Figure 7.16 depicts the relationship between the activity pillar and the other pillars. The activity pillar is highlighted in this case, and the contributions of the other pillars to the activity pillar are shown. Industrial visits, co-curricular and extra-curricular events, specialist lectures, conferences, and workshops are among the activities. The number of activities carried out directly contributes to the overall development of the students. Each of the pillars contributes to the activity pillar.

- Admissions offer a forum for events to take place, but academics are the most significant factor.
- Academic support programs include expert lectures, workshops, conferences, project competitions, and so on.
- As previously stated, the quality of the activity is significant, and this is affected by collaborations with industries for carrying out activities. A provision should be made in the institute's annual budget.
- Co-curricular and extra-curricular activities demand quality facilities such as playgrounds, wifi, and so on, which is funded by the infrastructure pillar.
- The training department offers skill-based training programmes and assistance in the execution of industry-related activities that affect the activity pillar's efficiency.

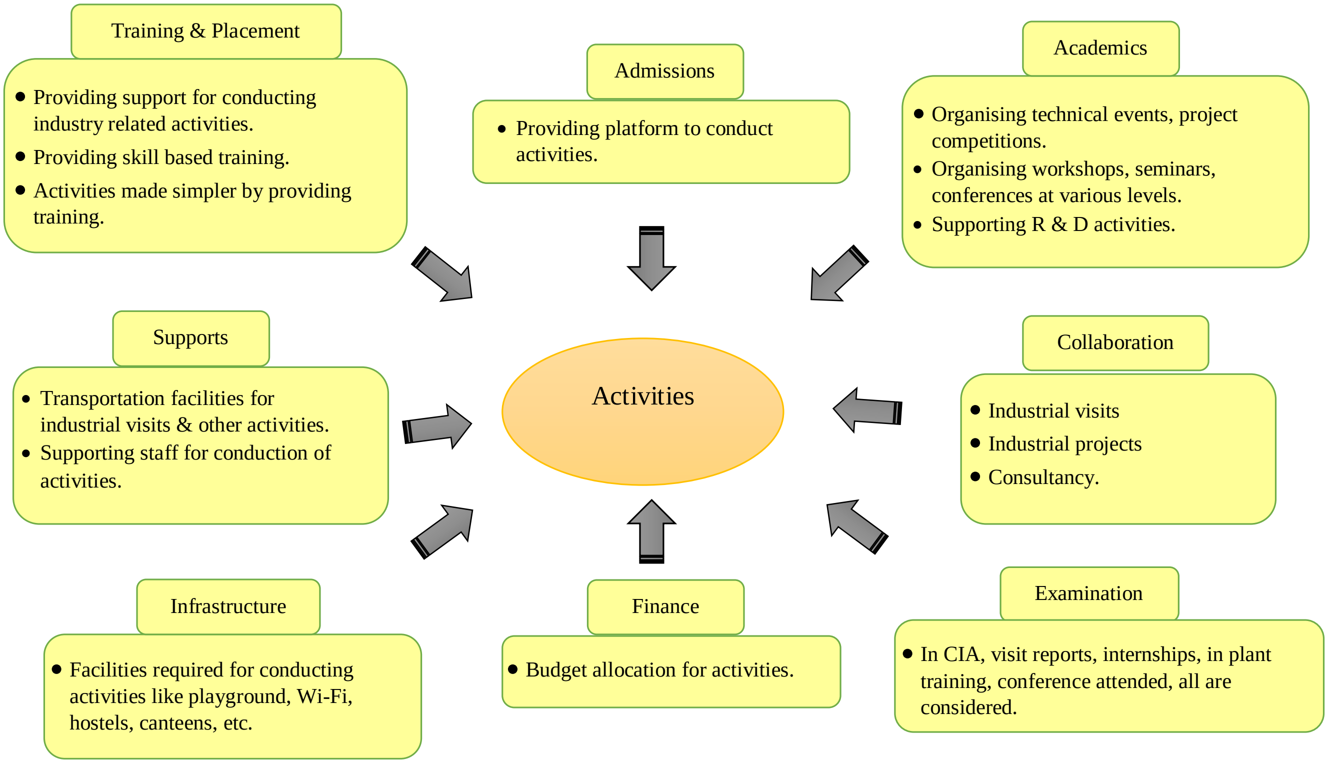

Figure 7-16 Linkage of activities pillar concerning others

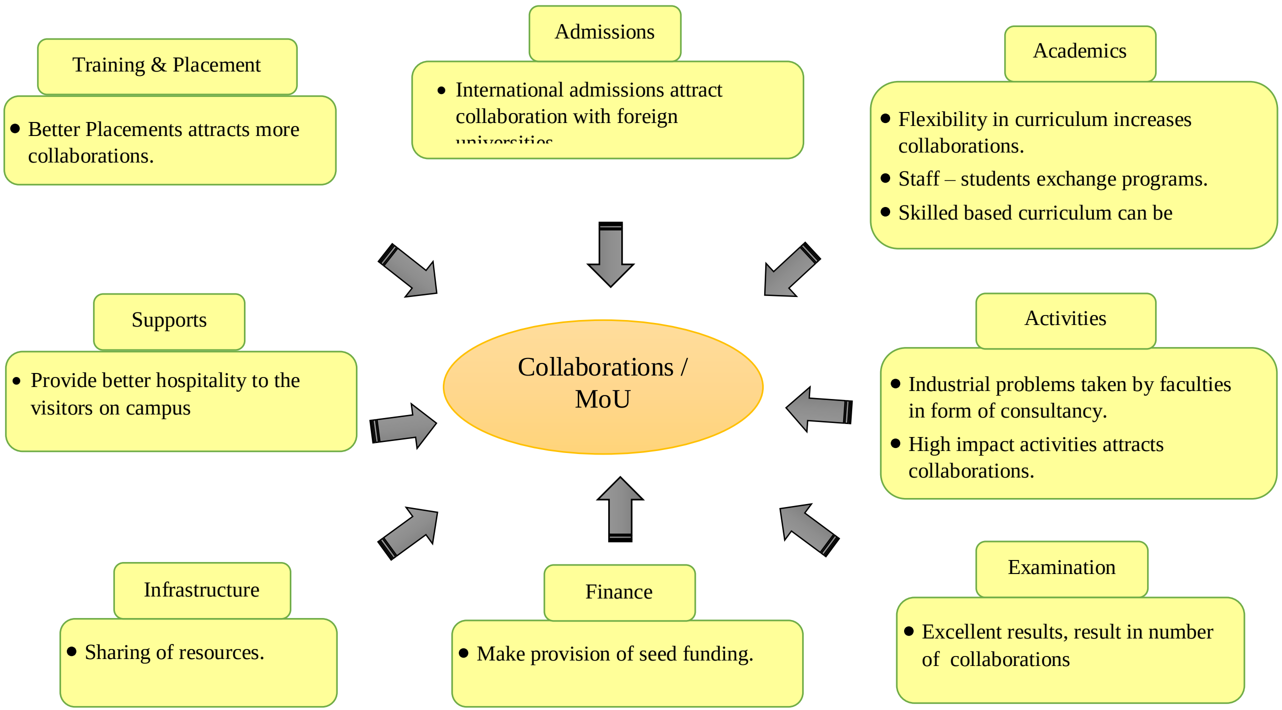

Figure 7-17 Linkage of collaborations / MoU pillar concerning others

7.10.4. LINKAGE OF COLLABORATIONS / MOU PILLAR WITH OTHERS

Figure 7.17 depicts how cooperation with industries benefits research activities significantly and creates the most skilled output from institutes. To solve complex engineering problems, industry and institutes should pool their technological expertise and knowledge. As a result, this is one of the most important pillars of TPE.

• Newly enrolled meritorious students excel academically, providing a useful workforce for the industry and attracting partnerships. International admissions broaden the opportunities for cooperation with foreign universities.

- Activities carried out attract partnerships and raise memorandums of understanding. Faculties accept industrial problems in the form of consultant or research problems, which improves students' problem-solving skills and increases industrial tie-up.
- By including industry experts in curriculum design, academics help to enhance coordination and MOUs with industries. A skill-based program can be tailored to meet the needs of various industries. Collaboration may be used to carry out staff-student exchange programs.
- If seed funding is available at the institute level, it will contribute to further research activities, and finance pillar support will be available in this regard.
- Adequate infrastructure and services allow for collaboration with the industry to carry out research activities.
- The support pillar can help by ensuring proper hospitability to guests.
- Better placements attract more MOUs and collaborators with the institute.

7.10.5. LINKAGE OF EXAMINATION PILLAR WITH OTHERS

Fig 7.18 shows the Linkage of the exam pillar. The examination is the pillar that directly measures the output of any technical institute.

• The system's effectiveness is determined first and foremost by admissions. If the system has a strong reputation, meritorious students would be drawn to enroll. They are the most valuable consumers, which impacts the exam results.

• A stronger and improved teaching-learning method has an effect on exam performance. Providing enough research materials, a book bank, access to an e-library, and a set academic calendar for academics all help to increase the outcome.

• Activities boost practical base learning, which improves the foundation for internships, and implant preparation, which improves students' reputation. They will earn additional credits that will be counted against their exam results.

• Finance offers a support structure for performing review activities by supplying remuneration and other funds needed for a smooth examination.

• The availability of adequate facilities ensures a smooth examination.

• Administrative assistance ensured that the examination was conducted fairly.

• Student training allows them to earn credits, which improves their grade.

The overall examination pillar has an influence on the effectiveness of every technical institute.

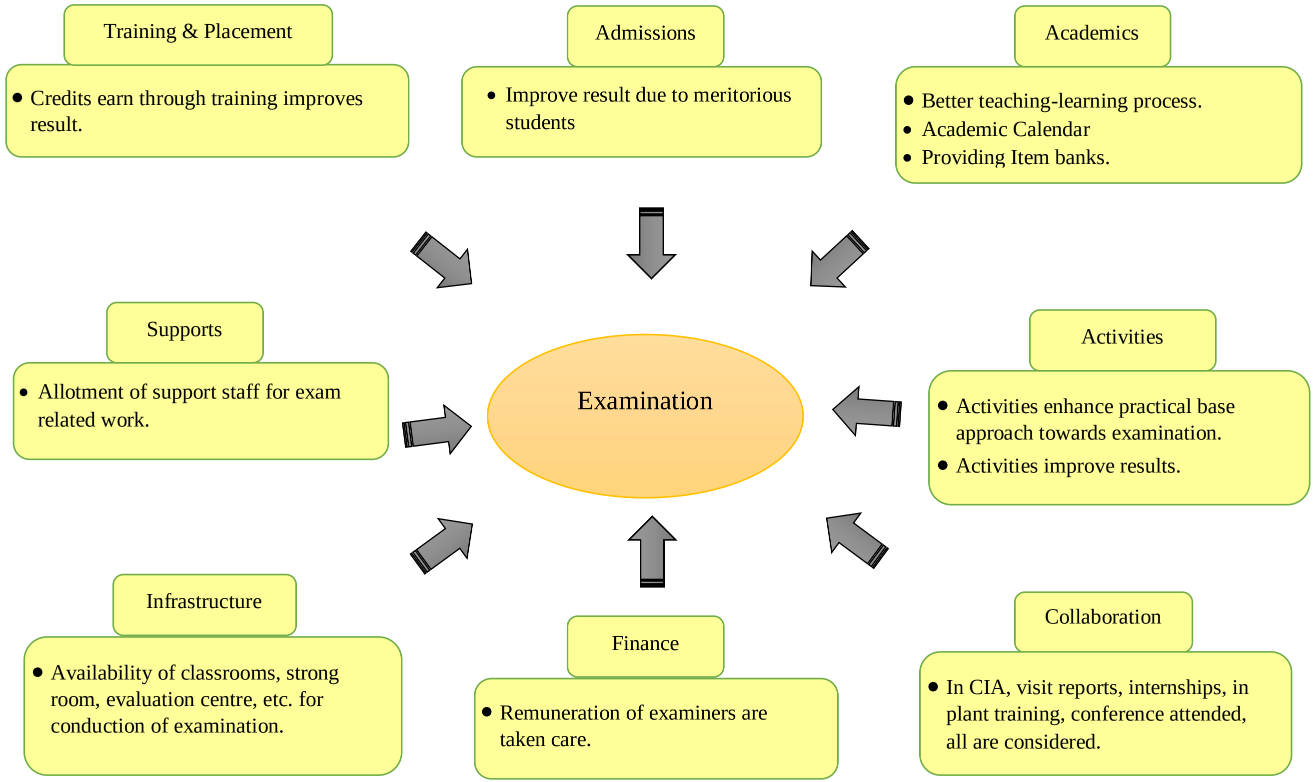

Figure 7-18 Linkage of examination pillar concerning others

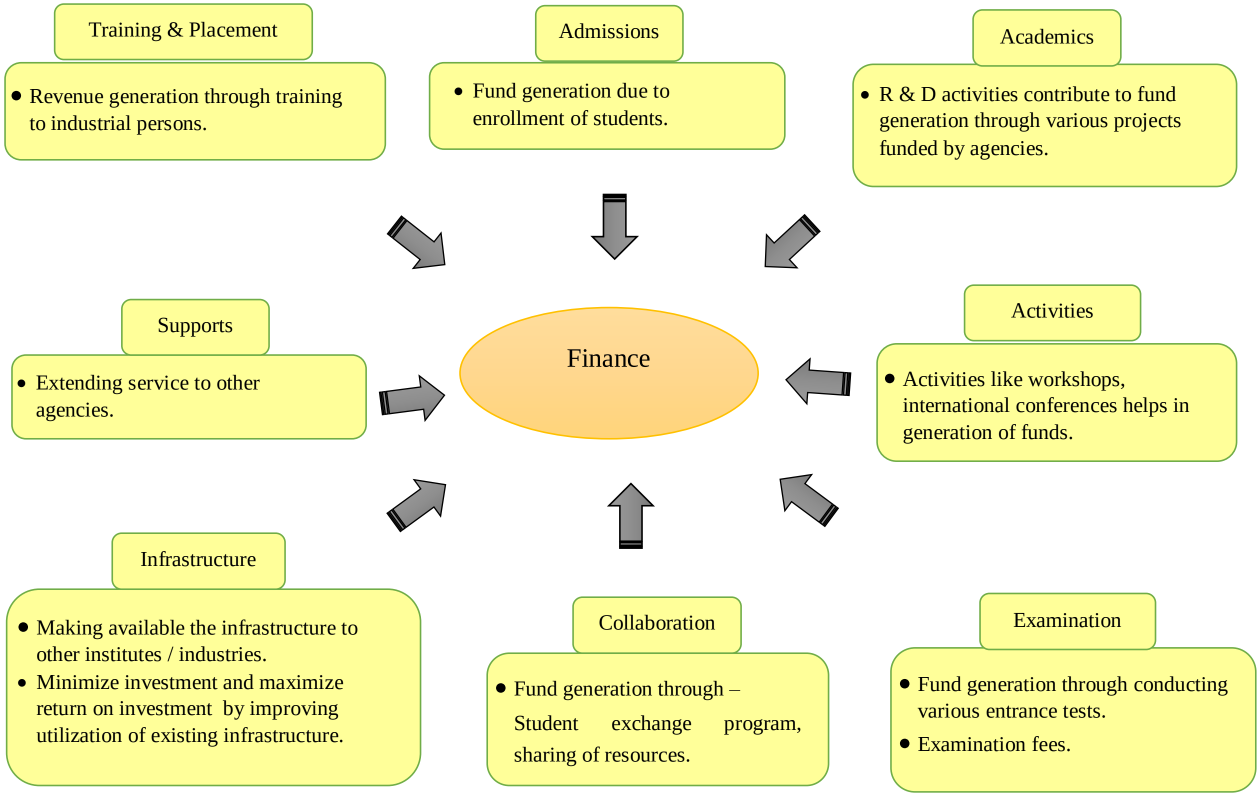

Figure 7-19 Linkage of finance pillar concerning others

7.10.6. LINKAGE OF FINANCE PILLAR WITH OTHERS

Figure 7.19 depicts the relationship between the finance pillar and the other pillars. All of the pillars in every technical institute are heavily reliant on the finance pillar. Each pillar must send its budget to the finance department at the outset so that budget distribution can take place.

• A large number of admissions ensures that funds are generated in the institute.

• R&D activities in conjunction with funding agencies will raise funds and directly impact academic quality.

• Collaborating with industries and offering consulting services aids the agency in raising funds.

• Organizing workshops, seminars, and conferences necessitates funds from the finance department, contributing to revenue generation.

• Holding external entrance exams and providing facilities will raise funds for the institute. Infrastructure sharing and proper utilization will generate funds for the institute.

• Infrastructure sharing and proper use will help to reduce costs.

• The training department will also raise funds by training factory workers.

7.10.7. LINKAGE OF INFRASTRUCTURE PILLAR WITH OTHERS

Fig 7.20 shows the Linkage between the infrastructure pillar and other pillars. The infrastructure of any institute doesn’t mean only the buildings. The equipment in the laboratory, books in the library, facilities in the classroom are also part of the infrastructure. Good and attractive infrastructure is the choice of the students. Every management tries to provide better infrastructure and invests largely in it. All other 8 pillars contribute towards the infrastructure.

- Starting with admission, no. of admissions can contribute to fundraising through development fees, which can improve infrastructure.
- If the proper mapping of courses is done, infrastructure can be shared and utilized effectively. Shift wise conduction of academics can reduce the burden on infrastructure.
- Proper planning of activities, collaboration with industries helps in sharing the infrastructure.
- Similarly, proper scheduling of examinations can reduce infra requirement.
- Support staff helps in maintaining the infra. Ownership feeling towards infra can be induced by training.
- Lastly, the finance department contributes towards infra by allocating budget.

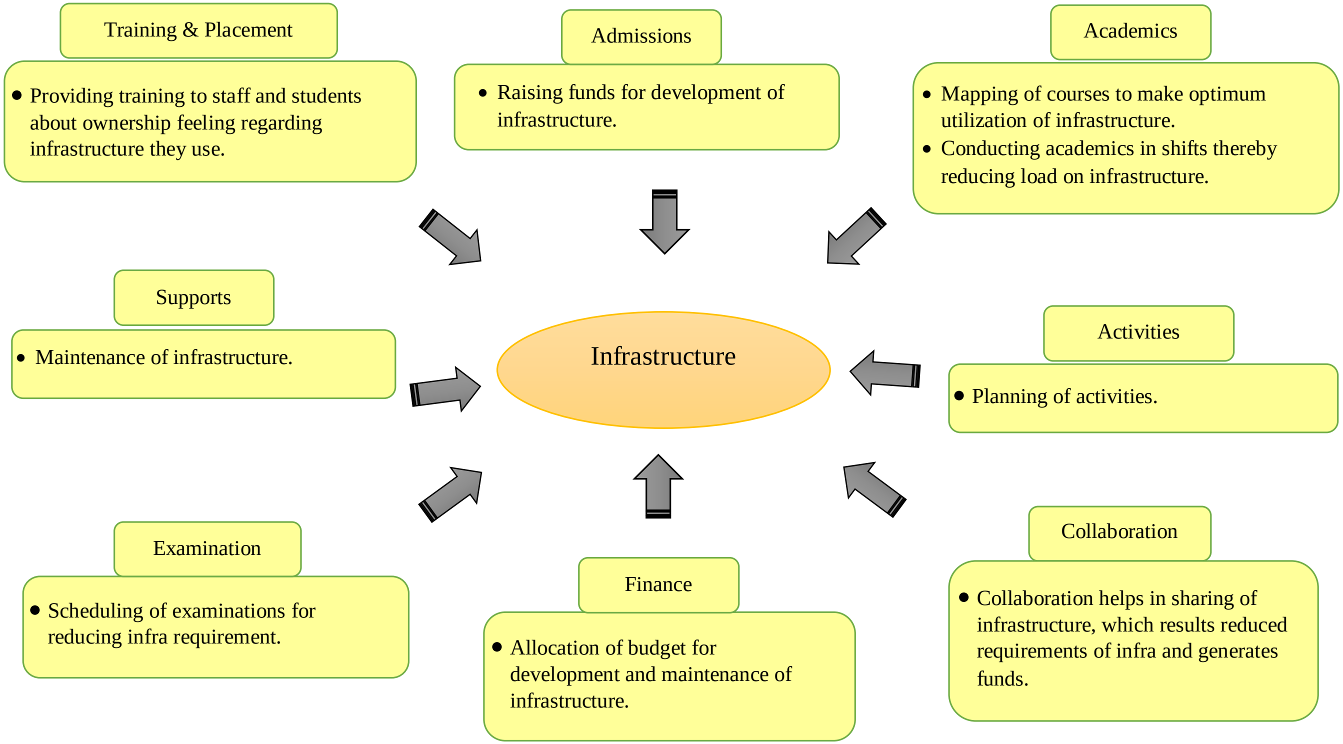

Figure 7-20 Linkage of infrastructure pillar concerning others

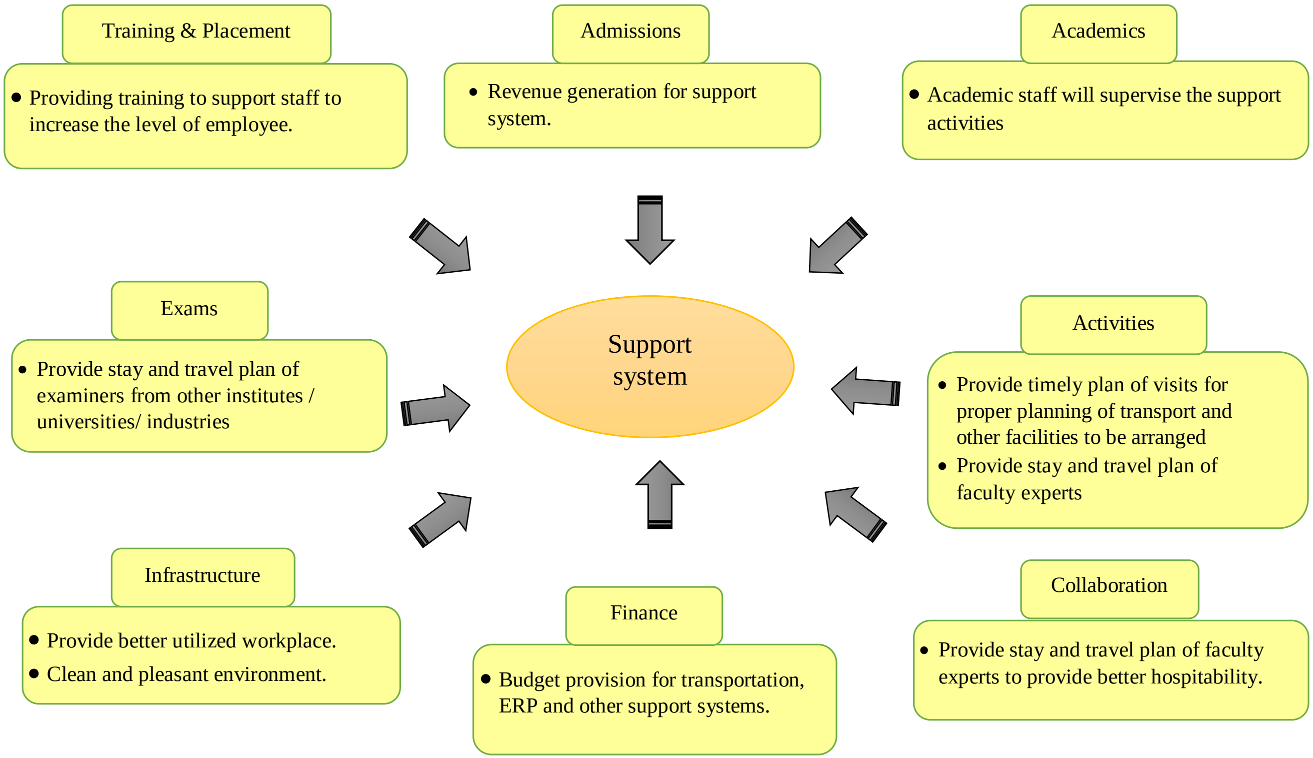

Figure 7-21 Linkage of Support system pillar concerning others

7.10.8. LINKAGE OF SUPPORT SYSTEM PILLAR WITH OTHERS

Fig 7.21 shows the Linkage between the support system pillar and other pillars. It is well said, ”growth of an organization is not decided by attractive infrastructure but by the workforce which runs it.” Therefore, the support system is one of the important pillars of the organization.

- The admission pillar ensures fund generation for the support system.
- Academics staff will supervise the support activities.
- Activity planning and scheduling will help the support system for arranging transport and stay facilities for the expert.
- The collaboration and exam section can give the stay and travel plan for the arrangement of stay and travel plan in advance for better hospitality.
- The training and placement department can provide training for managing and maintaining the infrastructure which can increase the level of employees.

7.10.9. LINKAGE OF TRAINING AND PLACEMENT PILLAR WITH OTHERS

Figure 7.22 depicts the relationship between the training and placement pillar and the other pillars. Aside from academics and infrastructure, the training and placement department is an essential department in which students are interested. The training department offers adequate training to students, preparing them for aptitude tests, personal interviews, and group discussions. Through contacting the industries, the placement department organizes campus interviews.

All the pillars contribute towards the T and P departments.

- Admissions ensure meritorious students get admitted, which are easy to place in industries.
- Academics enriches the skill by providing proper teaching and learning in support of activities.
- Collaboration with industries ensures proper internship which is considered for placement.
- The finance department helps in providing finance for T and P activities.
- The infrastructure department provides training, interview rooms, and other facilities required.

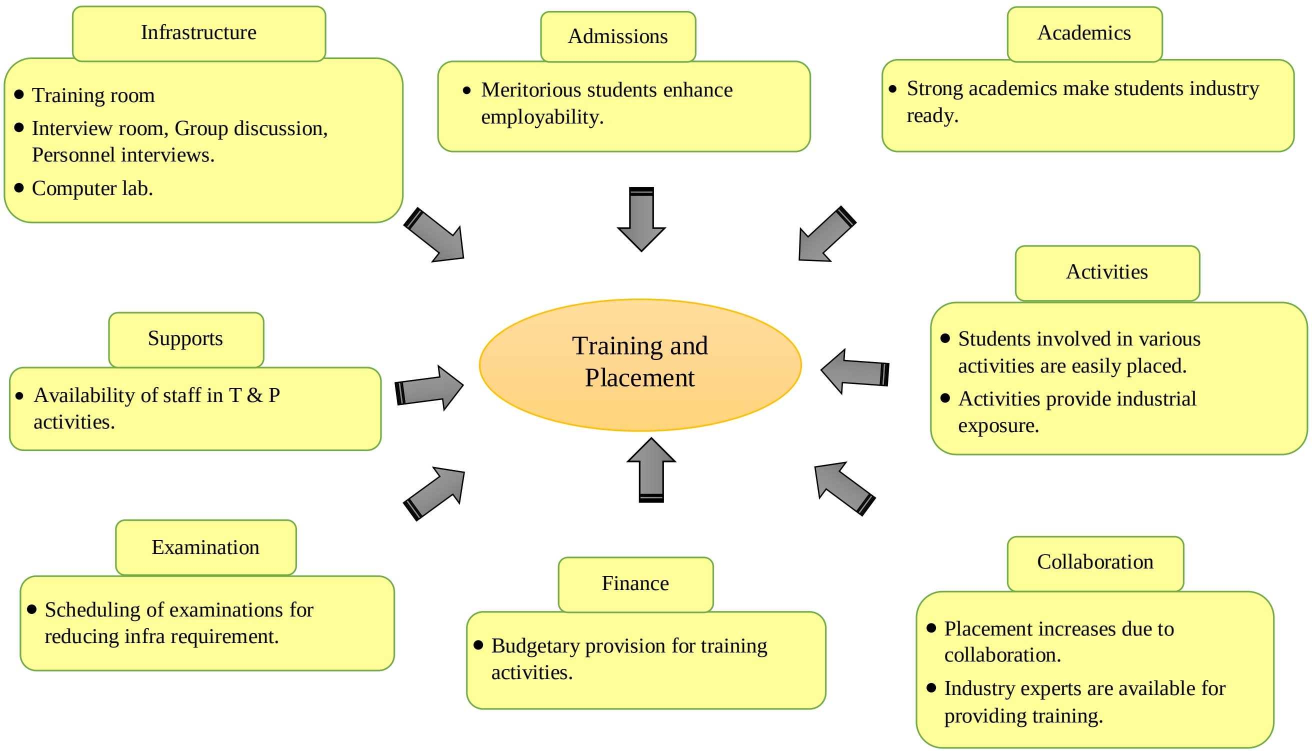

Figure 7-22 Linkage of training and placement pillar concerning others

CHAPTER 8. CONCLUSION

This chapter wraps up the research work outlined in this thesis. This section of the thesis highlights major contributions and findings, as well as summarises future work directions. TPM implementation fails at a high rate in India; the barriers are identified, and a ranking of TPM pillars based on the AHP approach is proposed. Effective use of TPM in the industry is noted, and the tools used for reducing losses to increase overall equipment efficiency are mapped for the education sector. The TPM model, which is widely used in industry, is applied to education, and the Total Productive Education (TPE) model is proposed for technical education in India..

8.1. CONCLUSION

Total Productive Maintenance (TPM) is a process that improves overall equipment efficiency, resulting in improved manufacturing industry performance. Chapter two discusses several success stories as well as obstacles. Given the low success rate of TPM implementation in Indian industries, the trigger found is a delay in decision-making by management regarding the value of the TPM pillars. Decisions are made based on experience and budgetary provisions, but it is difficult since no quantitative methods or guidance are available. The TPM pillars were ranked according to the parameters and compared pairwise. The Analytical Hierarchy Process, as defined in Chapter 3, is a method for making multi-criteria decisions. However, no attempt was made to apply it to TPM.

To rank the TPM pillars with the AHP, a novel approach is used. The fourth chapter serves the objective of rating the TPM pillars based on the survey results. The survey data collected in Indian industries (automotive sector) is analyzed. The calculations are completed, and graphs are plotted using AHP. The outcome provides a ranking of TPM pillars based on four criteria: productivity, cost, quality, and delivery-in-time (PCQD). Pairwise comparison is made between the TPM pillars as well as the four PCQD criteria. Based on the available data, a pillar hierarchy is proposed. The results and the outcome of the AHP hierarchy provide a ranking of the pillars for the automative sector/manufacturing industries. According to the findings, the Autonomous maintenance pillar (JH) has a marginally higher weightage than the Focused maintenance pillar (KK). JH focuses on quality improvement, which increases efficiency. KK heavily influences productivity. By minimizing various losses, the output rate increases, resulting in delivery-in-time and a decrease in manufacturing costs. It is recommended to begin implementing TPM with the JH pillar, followed by the KK. Following that, the focus would be on the Preventive maintenance (PM) and Quality maintenance (QM) pillars. Once both of these pillars are in place, the operations of the Education and Training (ET) and Office TPM (OTPM) pillars will be added. Following that would be IFC and EHS.

The preceding research is for the automotive industry market. TPM pillar ranking is determined by expert feedback based on their expertise and the sector/industry in which the survey is conducted. However, adjustments can occur as a result of

individual judgments. The experts' opinions will differ depending on the company's segment, such as the chemical industry or the service industry, and the hierarchy of pillars will change. Analyses can be performed using the same tables. The obtained results and tables can be used to vary the ranking and obtain the ranking for the appropriate sectors.
The TPM model enhances productivity in industries; the survey in chapter two, which focuses on higher technical education in India, identifies the need for a similar model in the education sector. It is proposed to incorporate the TPM concept in the education sector to increase technical education productivity. The fifth chapter discusses AHP in education and identifies the criteria for this sector. The complex problem hierarchy is built using AHP literature.
In Chapter 6, based on the available literature, the criteria are validated by a survey conducted at Sandip University for 2769 students, defining the frequency of responses for AHP criterion. The challenges associated with higher technical education are defined based on input from staff and students. The responses are addressed in Chapter 6 with the case study conducted at Sandip University, with the help of AHP and survey-based research.
The generalized study of students from various institutes affiliated with the same (Pune) university is compared. Similarly, responses from students at different universities in Pune and Sandip are compared, and the results show that the problems associated with higher technical education in India are similar. Sandip University offered and implemented solutions to the identified problems, such as implementing Yoga, sports, counseling sessions, supplementary exams, teaching-learning, and so on, which resulted in improved student success. The findings show that incorporating tools into education improves the institute's effectiveness. Input from chapters 5 and 6 serves as a foundation for developing the educational system's pillars.

The TPM and AHP, along with the survey results, form the basis for proposing the Total Productive Education model. The TPE model for higher technical institutes in India is proposed in Chapter 7. This topic contributes to the mapping of TPM implemented in the industry in collaboration with the technical institute. For industry and institutes, a schematic correlation in terms of TPM -Total, Productive, Maintenance - is performed. The action and goal (of minimizing losses) of the TPM's eight pillars in the industry are mapped with the action and target (of minimizing the problems identified) of educational institutes. The comparison/mapping was done for the 16 major losses in industries with technical institute problems. The interrelationship of each pillar of education with respect to another pillar of education is described. TPE model proposed is the new model to enhance the productivity of Technical education. The proposed TPE model is built on nine pillars to address the student and staff issues found in the survey report. As the TPM pillars reduce industry losses, each pillar has a particular task to solve/remove/minimize the problem. TPE's pillars are as follows:

1. Admission
2. Academic

3. Activities
4. Collaborations/MoU
5. Examination
6. Finance
7. Infrastructure
8. Support Systems
9. Training and Placement

The TPE model tackles the issue of higher technical education institutes in nine proposed pillars, ranging from low enrollment ratio to employability. The discussion provides a comprehensive justification to choose the pillar, activities of the pillar, issues and actions needed, and the TPM resources to be used. Sandip University has adopted the methods suggested for problem resolution. Activities such as project-based learning and activity-based learning are used to improve the teaching-learning process, and the results are illustrated with photographs in Chapter 6. Students are granted industrial visits, expert lectures, industrial ventures, and internships to boost their industrial knowledge. The activity carried out aided in the enhancement of the student's skill set, thus increasing the effectiveness associated with the teaching-learning process. TPM improves industry efficiency, while TPE improves institute effectiveness and increases the competitiveness of the technical education system.
TPE model design for higher technical education, which has never been done before. The identification of nine pillars using AHP will resolve educational losses/problems and thus solve the issues using various TPM tools.

8.2. FUTURE SCOPE

There is always scope to develop and expand the work in order to advance in the area of application. The following are suggestions for future work on the TPE model:

• Nine TPE pillars are proposed, with technical education serving as the foundation. • There is room to incorporate any missing pillars. • The TPM tools suggested for problem-solving in TPE are minimal, and other tools may be added if found to be useful.

• The comprehensive maps, process papers, working guides, and so on that will be created in preparation for the TPE's implementation.

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APPENDICES

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Appendix A. Response for Ranking of Pillars

Total Productive Maintenance for Industrial Excellence:

TPM Pillars

Sr No.	Pillar	Abbreviation
1	Jisu Hozen (Autonomous Maintenance)	JH
2	Kobestu Kaizen(Focused Improvement)	KK
3	Preventive Maintenance	PM
4	Education & Training	ET
5	Quality Maintenance	QM
6	Initial Flow Control (Maintenance Prevention)	IFC
7	Office TPM pillar	OTPM
8	Safety, Health & Environment	SHE

Rating Scale

Scale Degree of preference

Intensity of Importance	*Definition*	*Explanation*
1	Equal Importance	Two activities contribute equally to the objective
2	Weak or slight	
3	Moderate importance	Experience and judgment slightly favor one activity over another
4	Moderate plus	
5	Strong importance	Experience and judgment strongly favor one activity over another
6	Strong plus	
7	Very strong or demonstrated importance	An activity is favored very strongly over another; its dominance demonstrated in practice
8	Very, very strong	
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation

Quality

Rate the pillars in terms of their contribution related to Quality

Factor	Factor weighting Score – For Quality																	Factor
	More important than								Equal	Less important than								
Compare Contribution of JH with respect to other pillars in terms of Quality																		
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	KK
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	PM
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ET
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	QM
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of KK with respect to other pillars in terms of Quality																		
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	PM
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ET
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	QM
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of PM with respect to other pillars in terms of Quality																		
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ET
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	QM
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of ET with respect to other pillars in terms of Quality																		
ET	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	QM
ET	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
ET	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
ET	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of QM with respect to other pillars in terms of Quality																		
QM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
QM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
QM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of IFC with respect to other pillars in terms of Quality																		
IFC	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
IFC	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of OTPM with respect to other pillar in terms of Quality																		
OTPM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE

Note: The justification of rating factor can be given in the table at the end.

Quality									
		1	2	3	4	5	6	7	8
		JH	FI	PM	E&T	QM	ISC	OTT	SHE
1	JH	1	6	1	4	1	6	8	8
2	FI		1	0.5	0.5	0.5	1	6	8
3	PM			1	4	0.5	6	8	8
4	E&T				1	0.5	6	8	8
5	QM					1	8	8	8
6	ISC						1	1	4
7	OTT							1	4
8	SHE								1

Cost

Rate the pillars in terms of their contribution related to Cost

Factor	Factor weighting Score – For Cost																	Factor
	More important than								Equal	Less important than								
Compare Contribution of JH with respect to other pillars in terms of Cost																		
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	KK
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	PM
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ET
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	QM
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of KK with respect to other pillars in terms of Cost																		
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	PM
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ET
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	QM
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of PM with respect to other pillars in terms of Cost																		
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ET
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	QM
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of ET with respect to other pillars in terms of Cost																		
ET	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	QM
ET	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
ET	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
ET	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of QM with respect to other pillars in terms of Cost																		
QM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
QM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
QM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of IFC with respect to other pillars in terms of Cost																		
IFC	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
IFC	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of OTPM with respect to other pillars in terms of Cost																		
OTPM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE

Note: The justification of the rating factor can be given in the table at the end.

Cost									
		1	2	3	4	5	6	7	8
		JH	FI	PM	E&T	QM	ISC	OTT	SHE
1	JH	1	1	1	4	1	4	0.5	4
2	FI		1	1	6	1	6	1	6
3	PM			1	6	1	6	1	6
4	E&T				1	0.25	1	0.5	4
5	QM					1	4	1	6
6	ISC						1	0.5	4
7	OTT							1	8
8	SHE								1

Rate the pillars in terms of their contribution related to Delivery in Time

Factor	Factor weighting Score – For Delivery in Time																	Factor
	More important than								Equal	Less important than								
Compare Contribution of JH with respect to other pillars in terms of Delivery in Time																		
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	KK
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	PM
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ET
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	QM
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of KK with respect to other pillars in terms of Delivery in Time																		
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	PM
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ET
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	QM
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of PM with respect to other pillars in terms of Delivery in Time																		
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ET
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	QM
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of ET with respect to other pillars in terms of Delivery in Time																		
ET	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	QM
ET	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
ET	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
ET	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of QM with respect to other pillars in terms of Delivery in Time																		
QM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
QM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
QM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of IFC with respect to other pillars in terms of Delivery in Time																		
IFC	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
IFC	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of OTPM with respect to other pillars in terms of Delivery in Time																		
OTPM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE

Note: The justification of the rating factor can be given in the table at the end.

Delivery in Time									
		1	2	3	4	5	6	7	8
		JH	FI	PM	E&T	QM	ISC	OTT	SHE
1	JH	1	0.5	0.5	4	1	6	0.5	6
2	FI		1	1	6	4	8	1	8
3	PM			1	6	1	8	1	8
4	E&T				1	2	4	2	4
5	QM					1	8	1	8
6	ISC						1	2	1
7	OTT							1	8
8	SHE								1

Productivity

Rate the pillars in terms of their contribution related to Productivity

Factor	Factor weighting Score – For Productivity																	Factor
	More important than								Equal	Less important than								
Compare Contribution of JH with respect to other pillars in terms of Productivity																		
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	KK
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	PM
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ET
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	QM
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of KK with respect to other pillars in terms of Productivity																		
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	PM
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ET
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	QM
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of PM with respect to other pillars in terms of Productivity																		
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ET
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	QM
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of ET with respect to other pillars in terms of Productivity																		
ET	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	QM
ET	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
ET	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
ET	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of QM with respect to other pillars in terms of Productivity																		
QM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
QM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
QM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of IFC with respect to other pillars in terms of Productivity																		
IFC	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
IFC	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of OTPM with respect to other pillars in terms of Productivity																		
OTPM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE

Note: The justification of the rating factor can be given in the table at the end.

Productivity									
		1	2	3	4	5	6	7	8
		JH	FI	PM	E&T	QM	ISC	OTT	SHE
1	JH	1	2	1	4	1	8	6	4
2	FI		1	4	6	4	8	6	6
3	PM			1	6	1	8	6	6
4	E&T				1	0.5	6	4	4
5	QM					1	8	6	6
6	ISC						1	0.5	0.5
7	OTT							1	4
8	SHE								1

Comparison of PCQD with respect to each other

Considering the criteria's Productivity (P), Cost (C), Quality (Q) and Delivery in time (D), rate the importance of each with respect to each other

Factor	Factor weighting Score – For Productivity																	Factor
	More important than								Equal	Less important than								
Compare IMPORTANCE of QUALITY with respect to Cost, Delivery in Time AND Productivity																		
Q	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	C
Q	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	D
Q	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	P
Compare the IMPORTANCE of COST with respect to Delivery in Time and Productivity																		
C	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	D
C	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	P
Compare the IMPORTANCE of Productivity with respect to Delivery in Time																		
P	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	D

		1	2	3	4
	Criteria	Q	C	D	P
1	Q	1	4	2	1
2	C		1	0.5	0.17
3	D			1	0.5
4	P				1
	Total				

Name of Company: Reliable Business Excellence Solution

Address: Ambad, Nashik

Manager: Mr. Thombare

Ranking of TPM Pillars

Quality

Rate the pillars in terms of their contribution related to Quality

Factor	Factor weighting Score – For **Quality**																	Factor
	More important than								**Equal**	**Less important than**								
Compare Contribution of **JH** with respect to other pillars in terms of Quality																		
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	KK
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	PM
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ET
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	QM
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of **KK** with respect to other pillars in terms of Quality																		
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	PM
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ET
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	QM
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of **PM** with respect to other pillars in terms of Quality																		
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ET
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	QM
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of **ET** with respect to other pillars in terms of Quality																		
ET	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	QM
ET	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
ET	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
ET	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of **QM** with respect to other pillars in terms of Quality																		
QM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
QM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
QM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of **IFC** with respect to other pillars in terms of Quality																		
IFC	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
IFC	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of **OTPM** with respect to other pillar in terms of Quality																		
OTPM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE

Note: The justification of rating factor can be given in the table at the end.

Ranking of TPM Pillars

Cost

Rate the pillars in terms of their contribution related to **Cost**

Factor	Factor weighting Score – For **Cost**																	Factor
	More important than								**Equal**	**Less important than**								
Compare Contribution of **JH** with respect to other pillars in terms of Cost																		
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	KK
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	PM
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ET
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	QM
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of **KK** with respect to other pillars in terms of Cost																		
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	PM
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ET
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	QM
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of **PM** with respect to other pillars in terms of Cost																		
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ET
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	QM
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of **ET** with respect to other pillars in terms of Cost																		
ET	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	QM
ET	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
ET	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
ET	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of **QM** with respect to other pillars in terms of Cost																		
QM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
QM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
QM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of **IFC** with respect to other pillars in terms of Cost																		
IFC	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
IFC	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of **OTPM** with respect to other pillar in terms of Cost																		
OTPM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE

Note: The justification of rating factor can be given in the table at the end.

Ranking of TPM Pillars

Delivery in Time

Rate the pillars in terms of their contribution related to Delivery in Time

Factor	Factor weighting Score – For **Delivery in Time**																	Factor
	More important than								**Equal**	**Less important than**								
Compare Contribution of **JH** with respect to other pillars in terms of Delivery in Time																		
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	KK
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	PM
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ET
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	QM
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of **KK** with respect to other pillars in terms of Delivery in Time																		
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	PM
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ET
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	QM
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of **PM** with respect to other pillars in terms of Delivery in Time																		
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ET
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	QM
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of **ET** with respect to other pillars in terms of Delivery in Time																		
ET	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	QM
ET	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
ET	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
ET	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of **QM** with respect to other pillars in terms of Delivery in Time																		
QM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
QM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
QM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of **IFC** with respect to other pillars in terms of Delivery in Time																		
IFC	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
IFC	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of **OTPM** with respect to other pillar in terms of Delivery in Time																		
OTPM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE

Note: The justification of rating factor can be given in the table at the end.

Ranking of TPM Pillars

Productivity

Rate the pillars in terms of their contribution related to Productivity

Factor	Factor weighting Score – For **Productivity**																	Factor
	More important than								**Equal**	**Less important than**								
Compare Contribution of **JH** with respect to other pillars in terms of Productivity																		
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	KK
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	PM
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ET
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	QM
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of **KK** with respect to other pillars in terms of Productivity																		
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	PM
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ET
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	QM
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
KK	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of **PM** with respect to other pillars in terms of Productivity																		
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ET
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	QM
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
PM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of **ET** with respect to other pillars in terms of Productivity																		
ET	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	QM
ET	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
ET	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
ET	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of **QM** with respect to other pillars in terms of Productivity																		
QM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	IFC
QM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
QM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of **IFC** with respect to other pillars in terms of Productivity																		
IFC	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM
IFC	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE
Compare Contribution of **OTPM** with respect to other pillar in terms of Productivity																		
OTPM	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	SHE

Note: The justification of rating factor can be given in the table at the end.

Ranking of TPM Pillars

Comparison of PCQD with respect to each other

Considering the criteria's Productivity (P), Cost (C), Quality (Q) and Delivery in time (D), rate the importance of each with respect to each other

Factor	Factor weighting Score – For **Productivity**																	Factor
	More important than								**Equal**	**Less important than**								
Compare IMPORTANCE of **QUALITY** with respect to Cost, Delivery in Time AND Productivity																		
Q	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	C
Q	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	D
Q	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	P
Compare IMPORTANCE of **COST** with respect to Delivery in Time and Productivity																		
C	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	D
C	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	P
Compare IMPORTANCE of **Productivity** with respect to Delivery in Time																		
P	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	D

		1	2	3	4
	Criteria	Q	C	D	P
1	Q	1			
2	C		1		
3	D			1	
4	P				1
	Total				

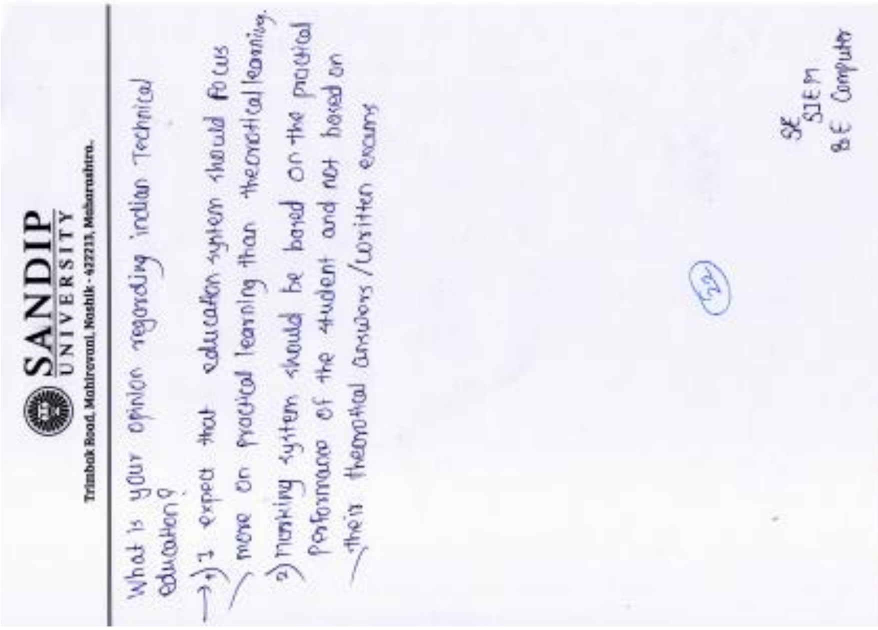
		1	2	3	4
	Criteria	Q	C	D	P
1	Q	1			
2	C		1		
3	D			1	
4	P				1
	Total				

Name of Company: Bagla Total Solutions

Address: Aurangabad, INDIA

Manager: M/s. B.R. Desale.

Appendix B. Student responses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What is your opinion regarding indian Technical education?

→1) I expect that education system should focus more on practical learning than theoretical learning.

2) marking system should be based on the practical performance of the student and not based on their theoretical answers/written exams

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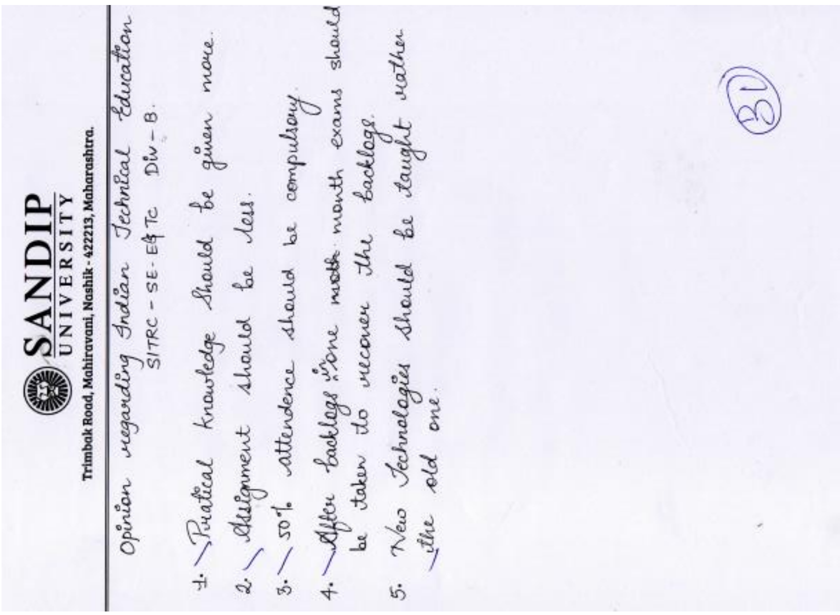
SE
SIEM
BE Computer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Opinion regarding Indian Technical Education

SITRC - SE - E&TC DIV - B.

1. Practical knowledge should be given more.
2. Assignment should be less.
3. 50% attendence should be compulsory.
4. After backlogs in one ~~moth~~ month exams should be taken to recover the backlogs.
5. New Technologies should be taught rather the old one.

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Opinion Regarding Indian Technical Education.

SITRC,
Mechanical Department.

The current scenario in our Technical field does not include practical knowledge. there is a huge gap to be breached between the practical and theoretical knowledge. We are not able to apply our basics on the practical field due to lack of practical knowledge and internships. In my point of view, final year should include 6 months (atleast) for internship to impart practical knowledge and best exposure to any external authorities (company). He can absorb the industrial surrounding readily and also he will be able to develop skills which he is in need of. He won't be remained jobless as he has the skills and he would master those skills and can get job easily. So, there would be no job scarcity. And also he would be paid accordingly as he is the master in his field.

(80)

More related to technical field, the semesters are just made such that there is no space for innovation and creativity. This institute should include workshops not weekly but should be more than 2 weeks or more.

They must impart the technical knowledge along with providing the practical application parallel to it. Softwares like Matlab and Ansys are very vital for our field which we are not been taught upto mark.

Also, this Exam pattern has bounded us to restrict our thinking capability. We are trapped in this system which can only be freed only by providing a practical based approach.

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BEIT (A)

~~Feed~~ opinion regarding facilities

1) EA Lab should be well maintained and fully prepared so that student doesn't need to share pc.

2) Fast and working internet should be available on every pc.

3) Enough number of Dot matrix printer should be available if ~~prints~~ are necessary.

Opinion regarding education

i) Regular sessions regarding new technologies and upgradations.

ii) Educational games like codearena for IT/Comp should be organised so that logic and coding skills would be improve

iii) Instead of assignments and completion we should force student get experience of industrie or participate in events, and marking should be on that basis.

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Opinion on Indian Technical education.

SITRC B.E. Mechanical.

- Technical education is always as important as the any other studies although it is a best education stream.
- Techineal education is lagging behind in private colleges due to only theoretical knowledge instead of practical knowledge.
- Innovation & idea creative should be developed in particular student.
- More face off to the current trends & affairs in technical advancement should be known to students.
- Industrial mind set and their technologies, working method, strategies should be taught instead of the more theoretical knowledge.
- Technical education system can be improved by improving the idea creation & potential of particular is to be checked.

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Opinion Regarding Technical Education.
TE - B, Mechanical Department., SUN

1] ~~Theories~~ Theory ~~subject~~ lectures should be reduced.
2] Practical ~~kno~~ exposure should be more.
3] Assignments should be less
4] More project work
5] Examination should be open book.
6] Supplementary exams should be take. twice.
7] Practical labs should be well equiped.

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56

Openion regarding ~~syllabus~~ Indian technical edecuation

SITRC, E&TC [BE]

- Insem should be stop. 100 marks theory paper should be conducted
- must concentrated on practical rather than theory paper.
- syllabus should be industrial practical bases rather than theory
- latest technology should be added in syllabus
- Personality development & communication skill based activity should added in syllabus
- half time slot ~~at~~ should allocated to practicals

4

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openion regarding
Indian Technical Education

SUN - TE- B- Mechanical

- Plese increse more practical sessions
- little bit syllubous is more so plese try to reduced syllubus.
- syllubus is regarding in industry work
- plese add new technology in our syllubus
- plese take supplemantry exams.
- exam is in theory paper is keep in 100 marks always
-

47

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SUN OPINION REGARDING INDIAN TECHNICAL EDUCATION

TE - (Mechanical) - B

1. Theory should be less, Practical should be more.
2. Teach with practical orientation.
3. Many points have been skipped, from the syllabus.
4. Assignments should be circulated different because one copies from other & the one who has written on his own gets less marks & than those who have copied it.
5. New technologies should be added.

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Opinion Regarding Technicaal Education

SoET
Mechanical Department.
Div - B (TE)

1) Assignment work should beless.
2) supplymentry Exam Should be Conducted after the Final Exam.
3) Industrial visit must be oriented.
4) Fifty - fifty Pattern should be Invented
5) Attendance Crieteria should be reduce.

17

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Opinion Regarding Technical Education :-

① A engineering syllabus is easy to understand, but theory ~~is~~ ~~was~~ purpose or point of view it is sufficient.

② But in practical point of view, it is less no. of practicle perform in machine.

③ Allow to supplientary exam.

④ Assignment submission is very high, it is cover is college lecture. Not for home.

⑤ New techonology are include in syllabus.

⑥ More ~~pro~~ important should be given to knowledge than the attendance.

⑦ Reduce attendance percentage.

⑧ Reduce assignment.

SOET,
Mechanical Department
Div:- B

18

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* opinion regarding Indian Technical Education".

- TE (Mechanical)
- SOET
- DIV-A.

* Our Syllabus should be practical oriented
* More industrial visit should be planned.
* Assignment should not be lengthy.
* Question bank should be given in examination.
* Proper Notes should be provided by concerned faculty.

8

B - Div
Mech - Dept
TE

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Opinion Regarding Indian Technical equcation

1) - I want to more Practical knowledge
2) Theory is ~~very~~ vast
3) They going to less industrial visit
4) we want to less assignment
5) we want to New techonology in our sylabus
6) They No, going to any Picnick
7) ~~To~~ Done the Sypplimentary exam
8) we want to sports lecture
9) They take the more exam fees
10) ~~They~~ we want the more Practical section
11) attendance should be 60%.
12) Time limit should be their in a class by entering the class

1

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* what is opinion regarding indian techical education ?.

→ not good, and sports should be involved and need many more improved

(7)

SUN B. Tech (CTIS)
3rd year.

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Opinion regarding Technical Education In India.

(i)

- Theortical assignment are given more.
- Syllabus taught in sandip University. is well good but it should not be in theoritical way. [practical + theoritical can be a better option. And due practical knowledge it is easy to learn new concept.]

Thanking You.

Sandip University
TE ME -(A)

6

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5] what is your opinion about Indian Technical education?

Ans : - In India we do not get technical knowledge.

- All we do is mug up or By heart useless defination which are not even used in industries.

- I would suggest to increase techinal (practical) session.

4

Jabir chaudhari
(8446413844)

SUN B.Tech (CTIS)
3rd year.

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UNIVERSITY
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Q. What is your opinion regarding indian techinal eduction?

It should be more focused on pratical or Industriy based education because It is more focused on theory.

- Sport Should be also be included in academics.
- Hands on industry tools must be used in academics.
- Latest technology Seminar should be conducted

8

SUN
TY ~~7~~ B.Tech (CTIS)

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Opinion regarding Indian technical Education

class S.E E&Tc Div-A
collage SITRC

according to My opinion Our current technical education focus on the Marks, assignments & attandance of Students rather than his skills practical Knowladge & ability to do a task So according to me Above mentioned all things are just redusing the ability of student this all things just diverting students from there goals by giving them stress of Assignments.

So According to me all such Practises in collage should be stoped & students should be treated as future reader of there ~~field~~ & given practical knowladge of there field rather then the ~~theoritical~~ work

Things which should be avoided

Compulsory Attandance	$\xleftrightarrow{\text{Replaced by}}$	weekly practical task
Assignments	⟷	Practical Knowladge,
Regular lecture	⟷	Saminars & field visits

(21)

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SITRC (SE)
E and TC Div- A

• Opinion :-

1. decrease to no. of lectures and increase no. of Practical because in Practical time student learn more then lect.
2. Student bored after lunch break so take half to 1 hour game Period. and also other activities.
3. Change the behavior of teachers teachers be like a ~~fer~~ friends Or brothe not like a boss.
4. ~~g~~ give the new information about electronics out of sylabus.
5. , motivate the Student to try new something

(34)

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Opinion Regarding Indian Technical Education
SITRC.
SE.A - E&Tc Department

Indian Technical Education is the supplementory base exam is conducted. So No Drop to the student because one year is waste this student. Attendance should be Not 75%. Only the 50% compulsory. Practical base education is the giving first priority than the theoratical.

Writing should be less. New Technology are used in the teaching. More industrial visits.

11

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opinion regarding Indian technical Education
class - SE, E&TC DIV-A
college - SITRC

1. Assignment should less.
2. more practical conducted than theory lecture.
3. writing should be less, New technology are used in teaching. → R&D

12

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37

Q. what is your openion regarding indian technical education

→ we know that the indian technical education is based on only theory syllabus. this system not only based on practical i.e. 80% practical & 20% theory. it is necessary to improve practical knowledge with needed skills in industries.

SIEM
B.E. ELECT
(B)

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Opinion Regarding Indian Technical Education.
EnTC Dept, SE-A, SITRC

→ More focus on Innovation knowledge culture.
→ Encouraging students for some interesting practicals.
→ Less Assingments.
→ Includding the latest industrial and technical knowledge in the syllabus rather than old one.
→ Not making the attendance compulsory.
→ Planning more industrial visits.
→ (Indian Technical education) → More Practical Focus, Industrial visits, Latest knowledge, Innovation culture.

→ Attendance 40% should be there.
→ It will be good if at least there ~~ter~~ should'nt be any discrimination between the fees.
→ If a person is really talented select him on his talent and ~~on~~ not on the reservation system, atleast in education.
Its because of this the real talented students are lagging behind and the ~~ret~~ all are going ahead due to this worst Reservation system.
SHAME ON THIS SYSTEM.

9

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19

SIEM :- Div C
DSE

* opinion about Indian technical Education :-

① lack of practical knowledge.
② No Inplant training.
③ only theory knowledge.
④ Students are not given freedom to perform there interest
⑤ Exams ~~decide~~ results decides students capabilities
⑥ Extra curriculum activities are not provided to students.

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SIEM

36

1) What is you opinion Regarding Indian Technical Education?

→ 1) In our country, there is lack of knowledge But Not practically Actually.
2) Need to be focus on practical knowledge & personal developement of students.
3) They the organisation should provide us Industrial Training.

SIEM
BE electrical
Div 'B'

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15

i) What is youe opinion about Indian Technical Education ?

→ i) Now, the Indian Technical education is bettee but we need Moee peactical knowledge than theoeitical knowledge

ii) Fees steuctuee should be same to all

iii) In Indian Technical education weite up (assignments) aee Moee than oue think

Sandip Insitute & Management. Nashik (DSE) 'C'

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43

Div.-C Mech. DSE ①

Q. What is ~~ope~~ your opinion about Indian technical education?

→ Indian technical education system is good. but we need some improvements in it. as no one can be perfect. our education system is not also perfect. wee need practical oriented syllybus as we see the syllabus of SPPU most topic is on theory. so as per my opinion we need improvement in following section.

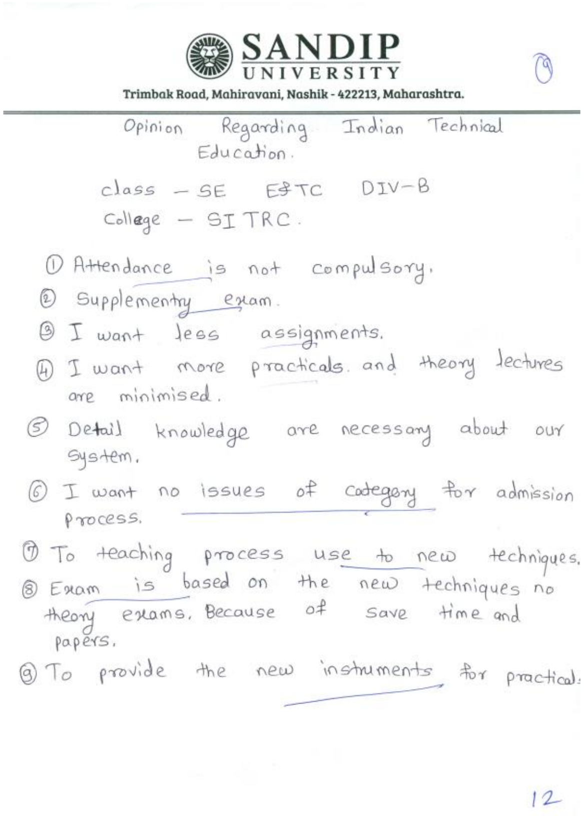
① we need to design practical based circulam.

② we ~~do~~ need to design circulum as like we produce a Entrepruner not a Engineer only

③ there are many encapetment should on the basic of leadership & teamwork.

④. and we need to study about latest education so I think wee need time to time evaluation of syllabus & change the circulum as need of time.

⑤



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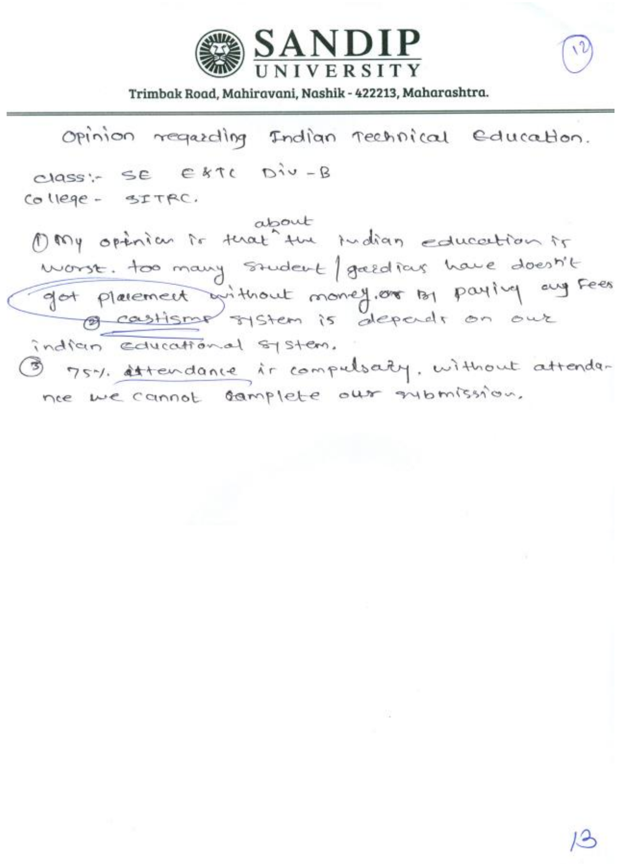
9

Opinion Regarding Indian Technical Education.

class – SE E&TC DIV–B
College – SITRC.

1. Attendance is not compulsory.
2. Supplementry exam.
3. I want less assignments.
4. I want more practicals. and theory lectures are minimised.
5. Detail knowledge are necessary about our system.
6. I want no issues of category for admission process.
7. To teaching process use to new techniques.
8. Exam is based on the new techniques no theory exams. Because of save time and papers.
9. To provide the new instruments for practical.

12



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12

Opinion regarding Indian Technical Education.

class:- SE E&TC Div - B
College - SITRC.

1. My opinion is that about the Indian education is worst. too many student / gardians have doesn't got placement without money. or by paying any Fees
2. castisms system is depends on our indian educational system.
3. 75%. attendance is compulsary. without attendance we cannot complete our submission.

13

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38

Opinion ~~About~~ Regarding Technical Education.

SITRC,
Department : Civil
Div :- A   T.E

* Duration of lectures should be less.
* Practical based lect should be conducted.
* On every topic test should be conducted.
* No. of Assignment should be less.
* Site Visit.
* Some recreational session should be kept for students.
* Break time should be more.
* Doubt session should be ~~kept~~. conducted.

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- Opinion Regarding Indian Technical Education,
- SITRC - SEIT

- we want more practicals as compared to theory Studies.
- The Syllabus is too Vast. It needs to be simple & easy for better understanding.
- The Ratio Regarding Practicals & Theory studies Should be 80:20. 80% of practicals & 20% of Theory Study.
- Complexity of Syllabus is Very high as compared to the knowledge & Grasping power of Students. It Should get reduced.
- No exams (Theory) Should get Conducted. Instead of that, University Conducted practical sessions Should be there in order to improve technical skills & knowledge of students. And theory exam is of no use.
- All Latest technologies Should be in our Syllabus as to improve knowledge of Students in Latest technology.

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SITRC – civil Dept (TE)

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35

* openion ~~Regarding~~ Regarding Technical Education.

1> more site visit
2> Attendence is compusulory
3> Take regular class test
4> ~~Assignment~~ Less the Assignment
5> Less the submission
6> ~~les college~~ ~~tes~~ college time is early in morning.
7> ~~Le~~ more practicles.
8> written work should be less
9> more waltage to practicle marks.
10> ~~Hyr~~ Their should no be year drop.

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36

Opinion Regarding Technical Education.

SITRC civil Dep. - TE

(1) To improve the quality ~~of~~ student's career in the future their should be more sessions about what they are going to learn and what work they are going to do in their future job

(2) more practicles should be give to the shoudents with refrence to their Dept.
like if student is of civil ~~in~~ the he/she should know how to do some practicle's like taking ~~PLs~~ which equipment should used for certain works

(3) The assignment's should be minimal as the are time consuming as no student write their assignment seriously

(4) Attendanu ~~th~~ should not matter until the student have ~~serain~~ secured it's position in good marking's

(5) Every subject should be given with it's model quepaper as with model que. paper students do study more

(6) more site visits should be done

(7) Carry forward should be their for good of students

(8) ~~Le~~ unifor should not matter

wensday
29/8/18

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SITRC
TE-CIVIL
31

Openion Regarding Technical education.

* Practical will be more campare to Theory lecture or Theory lecture converted into practical
* Site visits are more.
* Syllubus should be 100 marks (50 marks Theory + 50 marks online of practical)
* No Assignment because there are wastage of time.
* Arranged Sports lecture.
* Writing should be less.
* More wieghtage to practical marks)

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28

Openion. Regarding Technical Education. (SITRC) civil. (T.E)

- Attendence should not be necessory upto 75%.
- more practical knowledge required now a days so more practical is required.
- ~~Submet~~ Submission should not be more.
- Syllabus should be updated.
- more site visit required for knowledge.

TE CIVIL
SITRC

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19

Opinion regarding technical education

(1) Portion – The portion is outdated. The techniques which we are learning now-a-days are not bee being used from years. We want that the current technique which are used for construction or for any thing related to that must be added to our syllabus.

(2) Marking ~~sk~~ scheme – should be improved. The no. of questions should be increased and the marks should be reduced. like for ex. suppose there are Que 1 & Que 2

- Q1. (i) — ? (5)
  (ii) — ? (5)

  OR

  Q2 (i) — ?
  (ii)

  so this should be changed.

it should be like.

Q1. (i) ⟶ ? –(2)
(ii) ⟶ ? –(3)
(iii) ⟶ ? –(4)

OR

Q2 (i) — ? (2)
(ii) — ? –(3)
(iii) — ? –(4)

it should be like this (MARKING TECHNIQUE

(3) No. of ~~assignments~~ should be reduced, writting work should be reduced.

(4) Visits ~~should~~ should be increased

(5) ~~Practicals~~ & should be increased.

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18

Opinion Regarding Technical Education.

T.E [civil] SITRC,

- I think. Yearly wise exam is best compare to Semester pattern
- We know attendance or minimum attendance is compulsory but not more than 65%.
- In the new era we dosen't need work like vast compilation because it is not useful in today's Market.
- In between technical Education student also want financial Education to earn also, to Fulfil his Financial Education.
- Most of our syllabus is not useful in today's Market so, update it with market's updates.
- after basic studies student want to study in specification on one subject then no need to study other ~~subject~~ also.

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17

Opinion Regarding Technical Education

TE. Civil.

* Attendance should be reduced to 60%
* College time should be effective, the college consumes the important time of the day as its 10 to 5 excluding travelling time.
* No writing work like assignment, instead. assignment should be like preparing ppt, etc.
* Notes should be forwarded on email instead of making students write in class room.
* College timing should be reduced as you are consuming the major part of the day.
* Extra curricular activities should be promoted
* Only 5 day college in a week.

* College should appreciate the students for their success in exams...
* More field visit.
* More practical sessions
* Less lectures.
* Carrear Guidance.
* Nepotism should be avoided.

SITRC T.E [Civil]

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13

- Regarding Portion — Portion is outdated, what we learn is the base but new technologies and pratical knowledge is not involved.
- Practical assissment should be given out the 1 priority.
- Knowledge regarding competative exam should also be considered.
- Re-examination should be taken out in minimum time interval i.e approx 1month.
- Termwork should be the practical assignments not the theory notes.

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52

SITRC (Third year student), civil Dept, Div - A

1. more practical sessions
2. expert lectures
3. we want ~~may~~ more internship.
4. syllabus should on practical base
5. Assignment work should be less.

SITRC (TE civil) Div : A

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#3

Opinion regarding Technical Education :
SITRC (TE civil) . Div : A

1. More sitevisit.
2. More industrial involvement.
3. Needs more practical knowledge regarding to the subjects as well as other.
4. Assignment should be minimum.

SITRC (civil) TE

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6

Opinion Regarding Technical Education :

i) I think 50% practical & 50% Theory is required.

ii) for the students of BE Entranship is should be taken.

iii) Attendance should be allowed to be 65%.

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B1

OPINION REGARDING ANY TECHNICAL EDUCATION.
SITRC, TE CIVIL, DIV-A

i) Many times formula, taking in derivation are not known to student, reference for that particular formula should mentioned in syllabus, so that student can learn it easily.

ii) practical exams should be of more weightage in exam than theorotical exams, as student know the practical application of any theorotical quantity.

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SITRC
T.E
Civil.

B2

opinion Regarding technical education.

- Assignments should be minimum
- Attendance should be low. minimum 60 %.
- intership should be taken.

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Q.1. what is your opinion regarding Indian technical education.

⇒ In Indian technical education is best but our opinion is practical knowledge is more give to us.

24

STEM DSE comp

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Q. What is your opinion regarding Indian Technical Edu?

→ The Indian Technical Education is quite impressive about the Academic Results. But I think it lacks practical skills & real life scenario knowledge. Theory is conducted nicely / properly.

10

STEM
DSE
COMPUTER

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21

What is your opinion regarding indian technicial education.

→ The education must be little bit practical based. It should have little difference cirriculam other study activities. More practical workshops should be taken.

SIEM
TE COMP-A.

29

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11

Q1] what is your opinion regarding Indian technolg technical education

→

As Indian technology is as good as we see, furthe to get update is about to introduced some technical knowledge. Practical knowledge is lack. some practical application should be introduced, so that student can get ~~the~~ f. understand well

SIEM,
3rd year comp.

12

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1) What is your opinion regarding indian technical education ?

→ In indian education theorotical knowledge is more but technical knowledge is less which is very important.

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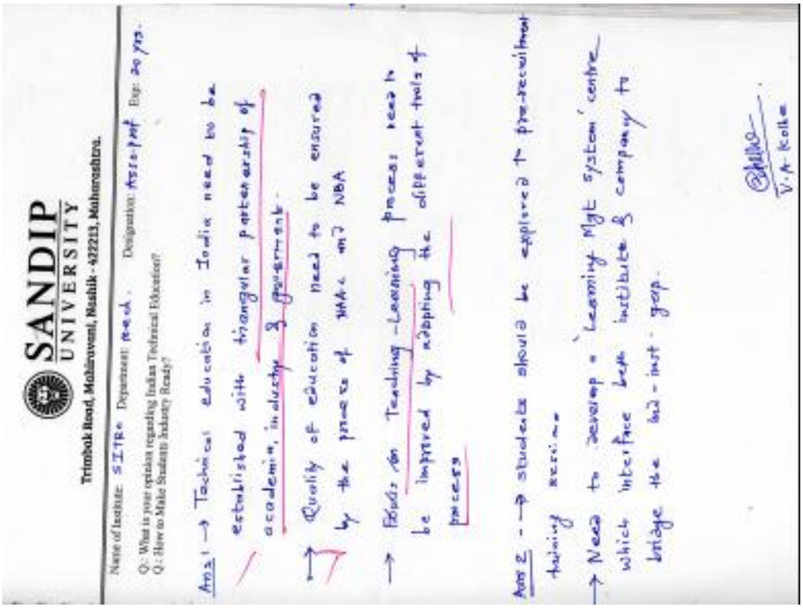
SIEM.
S.E (E&TC).

Appendix C. Staff Responses



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Trimbak Road, Mahiravani, Nashik - 422213, Maharashtra.

Name of Institute: SITRC Department: Mech. Designation: Asst. Prof. Exp: 20 yrs.

Q: What is your opinion regarding Indian Technical Education?
Q: How to Make Students Industry Ready?

Ans 1 → Technical education in India need to be established with triangular partnership of academia, industry & government.

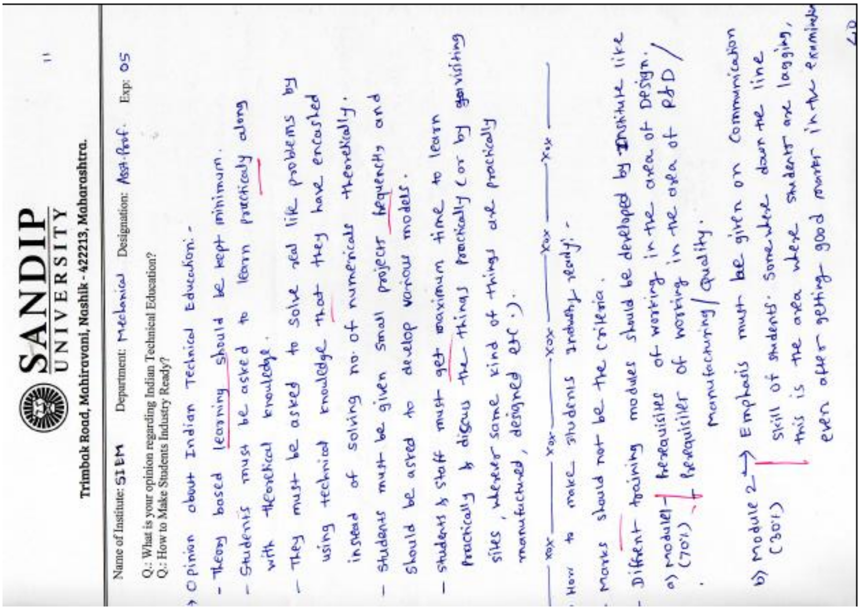
→ Quality of education need to be ensured by the process of NAAC and NBA

→ Focus on Teaching-Learning process need to be improved by adopting the different tools of process

Ans 2 → Students should be explored to pre-recruitment training session.

→ Need to develop a 'Learning Mgt system' centre which interface between institute & company to bridge the ind-inst gap.

V.A. Kolhe



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Trimbak Road, Mahiravani, Nashik - 422213, Maharashtra.

Name of Institute: SIEM Department: Mechanical Designation: Asst. Prof. Exp: 05

Q: What is your opinion regarding Indian Technical Education?
Q: How to Make Students Industry Ready?

→ Opinion about Indian Technical Education:-
- Theory based learning should be kept minimum.
- Students must be asked to learn practically along with theoretical knowledge.
- They must be asked to solve real life problems by using technical knowledge that they have earned instead of solving no. of numericals theoretically.
- Students must be given small projects frequently and should be asked to develop various models.
- Students & staff must get maximum time to learn practically & discuss the things practically (or by visiting sites, where same kind of things are practically manufactured, designed etc.).

—xox—xox—xox—xox—

- How to make students industry ready:-
- Marks should not be the criteria.
- Different training modules should be developed by Institute like
a) Module 1 (70%) – Prerequisites of working in the area of Design.
– Prerequisites of working in the area of R&D / manufacturing / Quality.
b) Module 2 (30%) → Emphasis must be given on Communication skill of students. Somewhere down the line this is the area where students are lagging, even after getting good marks in the examination.

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Name of Institute: SIEM Department: Electrical Designation: Asst Prof. Exp: 5yrs

Q.: What is your opinion regarding Indian Technical Education?
Q.: How to Make Students Industry Ready?

Ans.1 - Lacking Direction of Learning i.e. a person is learning everything but not focussed on a concept.

- Its more of Theory and certificate collection to prove your learning, but hands-on skill and working with hardware is less
- It lacks the Industry - Academic connection

Ans2 - There is a need to take students out of classrooms to practical field to witness the theory in action

- Projects & Seminars should be based on problems faced in industry and for this industry interaction needs to increase
-

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Name of Institute: SITRC Department: Mechanical Designation: Asst. Prof. Exp: 07

Q.: What is your opinion regarding Indian Technical Education?
Q.: How to Make Students Industry Ready?

* Indian Technical Education

1) The system is inclined towards imparting theoretical knowledge of subjects.

2) There is urgent need to increase weightage towards Practicals of subjects.

3) The education system is oriented towards engineers who are job aspirants.

4) The aim of education system should be development of industry ready engineers or entrepreuners.

* How to make students industry ready

1) To introduce latest technologies in syllabus.

2) To update syllabus every semester with inputs from industry.

3) To arrange regular interactions with industrial world.

4) To increase awareness about importance of Practicals over theory.

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2

Name of Institute: SIEM Department: ESH Designation: Asst. Prof. Exp: 10 yrs.

Q.: What is your opinion regarding Indian Technical Education?
Q.: How to Make Students Industry Ready?

A-1) - The general scenario of Indian Technical Education in recent times is not at par with the global quality standards of Education.
- Quality of education needs to be assessed at specific time intervals, which calls for a continuous assessment process.
- General education is at times put aside and technical education is given more importance, since the latter is expected to offer good opportunity for employment. However, this is not always true and hence, both these systems should go hand-in-hand.
- With an enormous population, only a handful of citizens are given apt consideration and opportunities in ITE, sometimes the deserving candidates are deprived of equal opportunities and they keep swaying for quality education.
- With a huge number of Technical institutes, our industries are yet in infancy and need technicians to man them.
- We are still importing lot of goods which proves that we lack skilled labours, thereby proving that a lot of improvement has to be inculcated in our technical education.

A-2) - Need to develop 'conceptual learnings'.
- skill-oriented education should be given to students.
- Developing more than one skill set among students, by means of value-added programs.
- Collaborate with good organizations so that students know where they are going to stand.
- Developing an attitude for research, team work and building, innovation, entrepreneurial skills among students.
- Hands-on training modules to be developed so that students are well prepared for real-life situations in industries and have adequate knowledge of dyna[mic] planning which is the need of the hour.

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Name of Institute: SIEM Department: Mech Designation: Asst-prof Exp: 5 years

Q.: What is your opinion regarding Indian Technical Education?
Q.: How to Make Students Industry Ready?

1) Indian Technical Education.
- Technical education should be research base as in IIT's & NITS. private engg institutions has to go as per university curriculum, there is very little scope for research. Hence Engg. institutions should have some autonomy as far as curriculum is concerned. So, curriculum should be research oriented. And lastly, Research should be such that, it should be beneficial to ~~sto~~ society, it should solve real life problems.

2) How to make students industry ready?
- Apart from technical knowledge ~~should~~ students should have skills like communication skills, writing skills etc. So in the curriculum it should be incorporated. And students should be technically sound, it can happen if curriculum is research based.

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11

Name of Institute: SIEM Department: Mechanical Designation: Asst-Prof- Exp: 05

Q.: What is your opinion regarding Indian Technical Education?
Q.: How to Make Students Industry Ready?

→ Opinion about Indian Technical Education: -
- Theory based learning should be kept minimum.
- Students must be asked to learn practically along with theoretical knowledge.
- They must be asked to solve real life problems by using technical knowledge that they have encashed instead of solving no. of numericals theoretically.
- Students must be given small projects frequently and should be asked to develop various models.
- Students & staff must get maximum time to learn practically & discuss the things practically (or by ~~go~~ visiting sites, wherever same kind of things are practically manufactured, designed etc.).

— xox — xox — xox — xox — xox —

→ How to make students Industry ready: -
- Marks should not be the criteria.
- Different training modules should be developed by Institute like
a) module 1 (70%) – Prerequisites of working in the area of Design.
– Prerequisites of working in the area of R&D / Manufacturing / Quality.
b) Module 2 (30%) → Emphasis must be given on Communication skill of students. Somewhere down the line this is the area where students are lagging, even after getting good marks in the examination

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SANDIP UNIVERSITY
Trimbak Road, Mahiravani, Nashik - 422213, Maharashtra.

Name of Institute: SITRC Department: Mechanical Designation: Asst. Prof. Exp: 07

Q.: What is your opinion regarding Indian Technical Education?
Q.: How to Make Students Industry Ready?

* Indian Technical Education

1) The system is inclined towards imparting theoretical knowledge of subjects.

2) There is urgent need to increase weightage towards Practicals of subjects.

3) The education system is oriented towards engineers who are job aspirants.

4) The aim of education system should be development of industry ready engineers or entrepreneurs.

* How to make students industry ready

1) To introduce latest technologies in syllabus.

2) To update syllabus every semester with inputs from industry.

3) To arrange regular interactions with industrial world.

4) To increase awareness about importance of Practicals over theory.

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Trimbak Road, Mahiravani, Nashik - 422213, Maharashtra.

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Name of Institute: SIEM Department: civil Designation: Exp:

Q.: What is your opinion regarding Indian Technical Education?
Q.: How to Make Students Industry Ready?

Technical education, the academic & vocational preparation of students for jobs involving applied science & modern technology. It emphasizes the understanding & practical application of basic principals of science & mathematics. Technical education gives students more than conventional education. The thinking ability of students. is improve by technical education. In current industry the recruiters required technically sound students rather than normal students.

Industry ready students can be prepared by
① Value added programmes in academics.
② The more practical base education will be included in syllabus.
③ Some Hands on practices should be adopted in syllabus.
④ Practical projects will be given to students.

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14

Name of Institute: Sandip University Department: - Civil Designation: Assistant Prof. Exp: - 4 Years.

Q.: What is your opinion regarding Indian Technical Education?
Q.: How to Make Students Industry Ready?

Indian Technical Education -

In India, the technical education consist various quries & required to rebuilt the structure of technical education.

The technical education is inclined more towards bookish knowledge than practical knowledge.

The way in which the preparation & ~~teaching~~ & Learning process in professional coarse is not appropriate because the students are study only within particular boundary. They don't go beyond the syllabus or their innovative ideas or skills they don't open or may be not getting chance to make them.

The technical education in India have a lot of gap bet practical & actual theory. A very less percentage co-ordination bet this two things & so the students/professionals have difficulty to implement their knowledge during their work.

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Name of Institute: S.I.T.R.C Department: Mechanical Designation: Asst. Professor Exp: 08 Yrs.

Q.: What is your opinion regarding Indian Technical Education?
Q.: How to Make Students Industry Ready?

As technical education is backbone of countries progress, Indian technical education has played significant role in the developement of our country. NIRF, NPTEL and Swayam programs are helping for enrichment of technical education system. But for non-IIT or non-government institutes, industry interface is major issue. Technical education should include soft skill and hard skills.

To make engineering students industry ready, engineering curriculum has to be revised. As engineering degree is 4 year program, last 06 months of this program should be utilised to train students in a particular skill of engineering. Instead of one year project, students should be asked to registered for one of the skill developement program. These programs should be run by the institute. These programs will be offered for advanced skills that required by the industry in present. Faculties of the institute should be asked first to get trained in particular skill. Then he will work as a mentor of that particular skill developement program. With this, students along with engineering degree, will acquire one such advanced skill that can help him to get a job.

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Name of Institute: SoET Department: EE Designation: Asst. Prof Exp: 17

Q.: What is your opinion regarding Indian Technical Education?
Q.: How to Make Students Industry Ready?

Ans-1

1) Wide-spread network of Indian Technical Education need to be standardised in view of
a) quality education
b) Practical exposure
c) student centric
d) Minor projects
e) Focus on Personality development
f) Communication skill
g) Evaluation is done on the basis of Practical skill rather ~~the~~ only on theorical writting.

Ans-2

a) Curriculum based on industry requirement
b) Regular interaction between industry & Academics
c) Evaluation System ~~may~~ ~~have~~ must include Assignments / Projects / minor Projects. which is being Evaluated by Industry expert only
d) Project work / Dissertation / Thesis work must based on real time Problem.

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6

Name of Institute: SOET Department: Mech. Designation: Asst Prof Exp: 7 yrs.

Q.: What is your opinion regarding Indian Technical Education?
Q.: How to Make Students Industry Ready?

Q1:- (1) Criteria to take admission for any Technical course should be made stringent so that good quality of students will get enrolled. Without good quality student having passion towards education no fruitful outcomes of education can be achieved.

(2) In todays education there is need of implementing value education so as to make students responsible for the development of India & society

(3) The student should publish atleast one research paper to get degree certificate & also quality of project should be very good. Now a days many students get readymade project which kills their creativity & innovative ideas.

Q2:- (1) Internship should be made mandatory in each ~~at~~ academic year

(2) All projects must be sponsored by industry or atleast beneficial for the society.

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8

Name of Institute: SITRC Department: IT Designation: Asst. prof. Exp: 11 yrs

Q.: What is your opinion regarding Indian Technical Education?
Q.: How to Make Students Industry Ready?

1. → ① Needs to meet requirement of rapid changes & developments in technology. There is no system to generate trained faculty for meeting diversified with an emphasis on specialization.

② There has to be a very close & continuous monitoring of the phenomenal technological advancement that have been taking place elsewhere in world in the emerging areas need to be observed & the respective courses & faculty are regularly & continuously updated from time to time.

③ polytechnics as well as degree colleges do not have inclination towards supporting the research & development due to the govt. lack of interest & support.

④ It is imerative that high technology in the fields modern science & engineering is evolved & utilized.

⑤ Additional measures will help to improve the quality of teaching-learning in engg. Exchange of faculty at inter-institutional & national or well as international levels.

Q. II →

① Industry - Institute interaction cell should be active throughout the year. &

② Student should have internship at industry such prom should be include in syllabus of each university.

③ student should have knowledge of basic skill soft skill & communication skill.

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(6)

Name of Institute: SITRC Department: Civil Designation: Asst-Prof Exp: 10 years

Q.: What is your opinion regarding Indian Technical Education?
Q.: How to Make Students Industry Ready?

1) Indian Technical Education system Concentrates more on acquiring information than on Creativity. This improves the memory of the student but does not encourage Creativity to do independent research.

I.T.E. involves a more theoretical approach rather than practical & skill approach.

2) In each semester Students get involved in Industrial Internship program &
1st 6 months of degree programe there should a Compulsary training for students with multinational Companies.
So it would make Industry Ready Students
** The program should be as per choice of Students

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(12)

Name of Institute: SITRC Department: Electrical Designation: Asst Prof Exp: 4 years.

Q.: What is your opinion regarding Indian Technical Education?
Q.: How to Make Students Industry Ready?

1. Indian Technical Education.
- Theoretically it is good & sufficient.
- Practicals are outdated & Pedagogies of practical are not upto the mark.
- List of practicals should be modified yearly. (reforms)

2. The 4 years of theory education should be reduced to 3 years covering the whole 4 years syllabus in 3 years.
- Last 1 year will be of production based in degree itself.
* eg: 1) Institute should have one production unit in which student will work for a year.
i) Student will work for a year.
2) Side by side production will take place & benifit for institute will be there.
3) Student will have the experience also in Quality, Manufacturing, Production, & Marketing.

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Name of Institute: SITRC Department: Comp. Engg Designation: Asst · Prof Exp: 8 yrs.

Q.: What is your opinion regarding Indian Technical Education?
Q.: How to Make Students Industry Ready?

1) → It is in expansion mode where fundamental characteristics are good but the implementation strategies possess some flaws.
→ Focus on OUTCOME BASED EDUCATION is lacking
→ PROBLEM AREAS - quality of students, quality of Faculty, infrastructure, external linkages, research, development, industry linkages, outdated curriculum.
→ Internationalisation within universities continues to develop apace as Institutions move from equating international strategy with international student recruitment to developing mature agendas that incorporate recruitment, research collaborations and capacity building.

2) → Industry personnel involvement in the overall education process is required.
→ Involvement in curriculum design and therefore, to acquire the skills which are required from students.
→ Students must interact and cope up with the industry procedures and technologies, culture.
→ To meet the demand and supply rule.
→ More internship, live project development can do better. 42

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Name of Institute: SITRC Department: E&TC Designation: Ass. Prof Exp: 2.3 yrs

Q.: What is your opinion regarding Indian Technical Education?
Q.: How to Make Students Industry Ready?

Q.1) Technical education that is education in some art or craft is the urgent need of the hour. technology is touching every aspect of life & Society. Since Independence, the technical education system in our country has grown into a fairly large-sized system, offering opportunities for education & training in a wide variety of trades & disciplines at a certificate, diploma, degree, PG & doctoral levels in institutions located throughout the country.

The general scenario of higher education in India is not equivalent with global quality stds. Hence, there is enough justification for an Incresed assesment of quality of country's educational institutions.

Q.2) 1) Make Skill oriented new course curriculum in all Streams & spheres of education
2) Using demonstrative teaching methodology to show the applicability of course content
3) Addition of value aided certification course along with professional degrees.
4) Enhancing Industry - Academic Institution connection thr CII.
5) Introduction of multi entry & multi exit course curriculum.

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Trimbak Road, Mahiravani, Nashik - 422213, Maharashtra.

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Name of Institute: SITRC Department: Computer Designation: Asst. Prof Exp: 10 yrs

Q: What is your opinion regarding Indian Technical Education?
Q: How to Make Students Industry Ready?

Q. How to make students industry ready ?

- Introduction of skill oriented new course curriculum in all streams of education.
- Using demonstrative teaching methodology to show the applicability of the course content.
- Addition of value aided certification courses along with professional degrees.
- Enhancing the industry - academic connection through Cofederation of Indian Industries (CII)
- Introduction of Stipend based summer internship programmes.
- Development of sound Entrepreneurship skills in the institution itself.
- Collaboration with foreign universities and institutes.

* To make students Industry Ready : -

1) Soft skill training : - Requires soft skill training for making students industry ready as well as to get & selected in the various company's placement process. It also includes various aptitude knowledge oriented training also.

2) Add-on courses / Employability oriented Courses : -
There is a need of various add on courses which students need to be acquired during graduation only so that their employability quotient & chances of selection will be higher.

3) Internship -
Every students must go & complete his/her industrial training during programme only to get practical exposure & knowledge. This will be getting additional skill set to be achieved by him/her & He/she will be benefitted in the placement / Job.

4) Industry Institute Collaboration (MoU's) -
Industry - Institute collaboration should be needed to become industry ready & this should be achieved with the following procedure / items
- By Expert talk / lecture
- In plant training by the faculty
- Training to be imparted by faculty to the industry personnel
- Taking / Identifying industry problem & deputing students for the same for finding solution (Project work)
- Publishing papers in collaboration with industry peoples
- Empanelment of industry personnel in the academic portfolio for syllabus upgradation / inputs
- Industrial visits
- Major softwares / industry practices & procedures to be followed by arranging training / talk / awareness programmes etc.

5) Alumni Interaction → Alumni sessions forms the major role to make students industry ready.

Appendix D. List of publications

The contributions have been as publications in journals and conference proceedings and are in a review in journal papers. The relevant publications are listed below:

A. Journal Publications:

1. **Dnyandeo Dattatraya Shinde**, Ramjee Prasad, “Total Productive Education: Model for Higher Technical Education,” Journal of Mobile Multimedia, Vol. 17 1–3, 1–26., 2021, River Publishers
DOI: 10.13052/jmm1550-4646.17131

2. **Dnyandeo Dattatraya Shinde**, Ramjee Prasad, “Application of AHP for Ranking of Total Productive Maintenance Pillars,” Wireless Personal Communications, Volume 100, Issue 2, May 2018, c,
DOI: 10.1007/s11277-017-5084-4
http://link.springer.com/article/10.1007/s11277-017-5084-4

3. **Dnyandeo Dattatraya Shinde**, Shwetambari Ahirrao, Ramjee Prasad, “Fishbone Diagram: Application to Identify the Root Causes of Student---Staff Problems in Technical Education,” Wireless Personal Communications, Volume 100 Issue 2, May 2018, Pages 653-664,
DOI: 10.1007/s11277-018-5344-y
https://link.springer.com/article/10.1007/s11277-018-5344-y

4. **Dnyandeo Dattatraya Shinde**, Ramjee Prasad, “Triangular model: Ultimate regime to enhance efficacy in Technical education.”, Journal of Engineering Education Transformations, Volume 33, No. 4, February 2020, pp -64-69, ISSN 2349-2473, eISSN 2394-1707,
DOI: 10.16920/jeet/2020/v33i4/149610

5. **Dnyandeo D. Shinde,** Ramjee Prasad, “Mobile Learning: Transforming Traditional Learning to e-learning,” International Journal in Emerging Trends on Technology, (IJETT), Volume 7, Issue 2, September 2020, ISSN: 2455-0124 (online), 2350-0808 (print)

A. International Conferences

6. **D. D. Shinde** and R. Prasad, "Digital Transformation in Technical Education," 2019 22nd International Symposium on Wireless Personal Multimedia Communications (WPMC), Lisbon, Portugal, 2019, pp. 1-4, DOI:10.1109/WPMC48795.2019.9096089.,
https://ieeexplore.ieee.org/document/9096089

7. **D. D. Shinde**, M. Srivastava and R. Prasad, "An Initiative to Enhance Productivity in Higher Education (Technical) Using Yoga Which

Interconnect Human Mind and Body," 2018 Global Wireless Summit (GWS), Chiang Rai, Thailand, 2018, pp. 190-193, DOI: 10.1109/GWS.2018.8686558., https://ieeexplore.ieee.org/document/8686558

8. **Dnyandeo D. Shinde**, Manas Srivastava, Ramjee Prasad, "Yog Nidra: a therapy to control human mind and body." International Conference on Emerging Trends in Management, Engineering, Law, Technology, and Science (ICEMELTS-2018), Dec 3 to 5 2018, Sandip University, Nashik, India.

9. **Dnyandeo D. Shinde,** Morten Falch, R.G. Tated, Ramjee Prasad, "Review of Indian Education System," IEEE 3rd International Conference on MOOCs, Innovation, and Technology in Education (IEEE MITE – 2015), Oct. 1-2 2015, Amritsar, Punjab, pp – 416-419, DOI: 10.1109/MITE.2015.7375356 https://ieeexplore.ieee.org/iel7/7369420/7375274/07375356.pdf

10. **Dnyandeo D. Shinde**, Morten Falch, R.G. Tated, Ramjee Prasad, "Ranking of Total Maintenance pillars using AHP," Global Wireless Summit, 18th International Symposium on Wireless Personal Multimedia Communications (WPMC'15), Dec. 13-15 2015, Hyderabad, India.

11. **Dnyandeo D. Shinde,** Morten Falch, R.G. Tated, Swetambari Ahirrao, Prachi Shinde, "Identifying Root Cause for Students Problems in Technical Education Using Fishbone Diagram," Global Wireless Summit, 18th International Symposium on Wireless Personal Multimedia Communications (WPMC'15), Dec. 13-15 2015, Hyderabad, India, Special Track – Manufacturing Engineering.

B. National Conferences

12. **Dnyandeo D. Shinde**, V.A. Kolhe, "An AHP Approach for Various Applications Review Paper," National Conference on Recent Trends in Mechanical Engineering RTME- 2013 (Met's Institute of Engineering) pages 89-93

Appendix E. Co-Author Statement

The co-author statement for the below-mentioned scientific contributions attached in the following pages.

1. Total Productive Education: Model for Higher Technical Education

AARHUS BSS SCHOOL OF BUSINESS AND SOCIAL SCIENCES
AARHUS UNIVERSITY

Declaration of co-authorship*

Full name of the Ph.D. student: **Dnyandeo Dattatraya Shinde**

This declaration concerns the following article/manuscript:

Title:	Total Productive Education: Model for Higher Technical Education
Authors:	**Dnyandeo Dattatraya Shinde**, Ramjee Prasad

The article/manuscript is: Published ☑ Accepted ☐ Submitted ☐ In preparation ☐

If published, state full reference: **Journal of Mobile Multimedia, Volume 17, Issue 1-3, pp. 1-26, January 2021, River Publication.**

If accepted or submitted, state journal:

Has the article/manuscript previously been used in other Ph.D. or doctoral dissertations?

No ☑ Yes ☐ If yes, give details:

The Ph.D. student has contributed to the elements of this article/manuscript as follows:

A. Has essentially done all the work
B. Major contribution
C. Equal contribution
D. Minor contribution
E. Not relevant

Element	Extent (A-E)
1. Formulation/identification of the scientific problem	B
2. Planning of the experiments/methodology design and development	A
3. Involvement in the experimental work/clinical studies/data collection	B
4. Interpretation of the results	B
5. Writing of the first draft of the manuscript	C
6. Finalization of the manuscript and submission	B

Signatures of the co-authors

Date	Name	Signature
12/02/2021	Ramjee Prasad	

In case of further co-authors, please attach an appendix

Date: 12/02/2021

____
Signature of the PhD student

*As per policy the co-author statement will be published with the dissertation.

2. Application of AHP for Ranking of Total Productive Maintenance Pillars

AARHUS BSS SCHOOL OF BUSINESS AND SOCIAL SCIENCES
AARHUS UNIVERSITY

Declaration of co-authorship*

Full name of the Ph.D. student: **Dnyandeo Dattatraya Shinde**

This declaration concerns the following article/manuscript:

Title:	Application of AHP for Ranking of Total Productive Maintenance Pillars
Authors:	**Dnyandeo Dattatraya Shinde**, Ramjee Prasad.

The article/manuscript is: Published ☑ Accepted ☐ Submitted ☐ In preparation ☐

If published, state full reference: **Wireless Personal Communications: An International Journal, Volume 100, Issue 2, pp. 449-462, May 2018.**

If accepted or submitted, state journal:

Has the article/manuscript previously been used in other Ph.D. or doctoral dissertations?

No ☑ Yes ☐ If yes, give details:

The Ph.D. student has contributed to the elements of this article/manuscript as follows:

- A. Has essentially done all the work
- B. Major contribution
- C. Equal contribution
- D. Minor contribution
- E. Not relevant

Element	Extent (A-E)
1. Formulation/identification of the scientific problem	B
2. Planning of the experiments/methodology design and development	A
3. Involvement in the experimental work/clinical studies/data collection	B
4. Interpretation of the results	B
5. Writing of the first draft of the manuscript	C
6. Finalization of the manuscript and submission	B

Signatures of the co-authors

Date	Name	Signature
18/05/2020	Ramjee Prasad	

In case of further co-authors, please attach an appendix

Date: 18/05/2020

Signature of the PhD student

*As per policy the co-author statement will be published with the dissertation.

3. Fishbone Diagram: Application to Identify the Root Causes of Student---Staff Problems in Technical Education

AARHUS BSS SCHOOL OF BUSINESS AND SOCIAL SCIENCES
AARHUS UNIVERSITY

Declaration of co-authorship*

Full name of the PhD student: **Dnyandeo Dattatraya Shinde**

This declaration concerns the following article/manuscript:

Title:	Fishbone Diagram: Application to Identify the Root Causes of Student---Staff Problems in Technical Education
Authors:	**Dnyandeo Dattatraya Shinde**, Shwetambari Ahirrao, Ramjee Prasad.

The article/manuscript is: Published ☑ Accepted ☐ Submitted ☐ In preparation ☐

If published, state full reference: **Wireless Personal Communications: An International Journal, Volume 100 Issue 2, May 2018, Pages 653-664**

If accepted or submitted, state journal:

Has the article/manuscript previously been used in other Ph.D. or doctoral dissertations?

No ☑ Yes ☐ If yes, give details:

The Ph.D. student has contributed to the elements of this article/manuscript as follows:

- A. Has essentially done all the work
- B. Major contribution
- C. Equal contribution
- D. Minor contribution
- E. Not relevant

Element	Extent (A-E)
1. Formulation/identification of the scientific problem	B
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3. Involvement in the experimental work/clinical studies/data collection	B
4. Interpretation of the results	C
5. Writing of the first draft of the manuscript	C
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4. Triangular model: Ultimate regime to enhance efficacy in Technical education

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Title:	Triangular model: Ultimate regime to enhance efficacy in Technical Education
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- A. Has essentially done all the work
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Element	Extent (A-E)
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2. Planning of the experiments/methodology design and development	A
3. Involvement in the experimental work/clinical studies/data collection	B
4. Interpretation of the results	B
5. Writing of the first draft of the manuscript	C
6. Finalization of the manuscript and submission	B

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5. Mobile Learning: Transforming Traditional Learning to e-learning

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3. Involvement in the experimental work/clinical studies/data collection	B
4. Interpretation of the results	C
5. Writing of the first draft of the manuscript	B
6. Finalization of the manuscript and submission	C

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6. Digital Transformation in Technical Education

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5. Writing of the first draft of the manuscript	C
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7. An Initiative to Enhance Productivity in Higher Education (Technical) using Yoga which interconnect human mind and body

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Title:	An Initiative to Enhance Productivity in Higher Education (Technical) using Yoga which Interconnect Human Mind and Body.
Authors:	**Dnyandeo Dattatraya Shinde**, Manas Srivastava, Ramjee Prasad.

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2. Planning of the experiments/methodology design and development	C
3. Involvement in the experimental work/clinical studies/data collection	B
4. Interpretation of the results	B
5. Writing of the first draft of the manuscript	C
6. Finalization of the manuscript and submission	B

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*As per policy the co-author statement will be published with the dissertation.

8. Yog Nidra: a therapy to control the human mind and body.

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Authors:	**Dnyandeo Dattatraya Shinde**, Manas Srivastava, Ramjee Prasad.

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The Ph.D. student has contributed to the elements of this article/manuscript as follows:

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5. Writing of the first draft of the manuscript	C
6. Finalization of the manuscript and submission	B

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No ☑ Yes ☐ If yes, give details:

The Ph.D. student has contributed to the elements of this article/manuscript as follows:

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- B. Major contribution
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3. Involvement in the experimental work/clinical studies/data collection	B
4. Interpretation of the results	C
5. Writing of the first draft of the manuscript	C
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Authors:	**Dnyandeo Dattatraya Shinde**, Morten Falch, R.G. Tated, Ramjee Prasad.

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2. Planning of the experiments/methodology design and development	B
3. Involvement in the experimental work/clinical studies/data collection	B
4. Interpretation of the results	C
5. Writing of the first draft of the manuscript	C
6. Finalization of the manuscript and submission	B

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11. Identifying Root Cause for Students Problems in Technical Education Using Fishbone Diagram

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Authors:	**Dnyandeo Dattatraya Shinde**, Morten Falch, R.G. Tated, Shwetambari Ahirrao, Prachi Shinde, Ramjee Prasad

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2. Planning of the experiments/methodology design and development	C
3. Involvement in the experimental work/clinical studies/data collection	B
4. Interpretation of the results	C
5. Writing of the first draft of the manuscript	C
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12. An AHP Approach for Various Applications Review Paper

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Authors:	**Dnyandeo Dattatraya Shinde**, Vikram Kolhe.

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No ☑ Yes ☐ If yes, give details:

The Ph.D. student has contributed to the elements of this article/manuscript as follows:

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1. Formulation/identification of the scientific problem	A
2. Planning of the experiments/methodology design and development	A
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5. Writing of the first draft of the manuscript	B
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Appendix F. Publications Pdf

Sr.	Title of Publication	Page numbers
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Total Productive Education: Model for Higher Technical Education

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Abstract

Industries need young engineers with proper Attitude, Skills, and Knowledge (ASK), ready to work from the first day without training. Technical education is the backbone for employment in industries. The demand and supply ratio is not matching due to lacunae in higher technical education. Industries are marching towards excellence with the implementation of Total Productive Maintenance (TPM) measured by Overall Equipment Efficiency (OEE). The paper focuses on how the TPM and its tools enhance education quality through the proposed model of Total Productive Education (TPE) for increasing the efficacy of the education system.

Keywords: Total productive maintenance, total productive education, TPM tools, higher technical education, engineering education, overall equipment efficiency.

1 Introduction

The development of any country depends on its youth power. The highly skilled and educated young workforce accelerates the technical sector.

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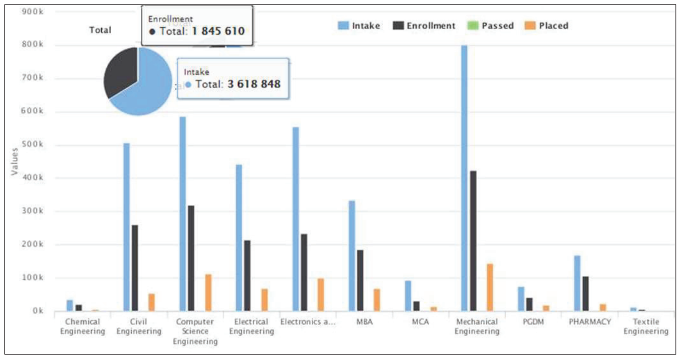


Figure 1 Engineering course wise employability (Source: India skill report 2019).

Engineering graduates with the latest skillset and research attitude will lead the nation to higher goals. The base of these graduates is engineering education. In the last decade, there is a tremendous increase in the number of technical institutes, which has drastically increased the intake of engineering seats. However, there is no significant increase in the employability ratio, which has started affecting the enrolment ratio of the students in technical institutes [1].

An annual National employability report 2019 of Aspiring Minds has quoted that – "The past nine years have brought no change in the employability of Indian engineering graduates. India's higher education system needs systemic change". The report states that more than 80% of Indian graduate engineers are unemployable due to a lack of knowledge and skills [2].

Figure 1 shows the coursewise enrolment and employability of engineering, MBA, and Pharmacy students for the academic year 2016–17. Figure 1 represents that there is an enrollment of 1845610 students against the intake of 3618848. Approximately 51% and the rest of the seats are vacant. It is less in a few institutions which are not able to maintain their quality. There is a need to focus on the low employability problem resulting in a low enrollment ratio of the students. Whereas, the reports also reflect the demand for highly skilled engineering graduates' increasing in the companies. Indicating that the higher technical education system needs a systematic change [3].

The India Skill report gives more details regarding the employability of engineers. Sectors that hired the most are software/hardware/manufacturing. It also represents that the candidates hired from the engineering domain in 2014 were 28%, in 2015 – 29%, and in 2019 it is 23%. Whereas for non-engineering MCA and M.Sc, it increased from 6% in 2014 to 11% in 2019. It represents that the hiring of engineering graduates has not increased as per the requirements. Further, there are chances that 40% of job loss in this sector because of technological advancement. Therefore, there is a need for skilling to reskilling. Future work will be in the form of Gigs. Gig worker is project-based where the person is not hired for a full-time job, whereas he is assigned the project with an assured outcome and get paid for it. They can work on multiple projects, requiring a more skilled workforce. The absence of industry connections also impacts students' employability. Electronics and communication, electrical, IT have ample internship opportunities where the student gains industrial experience. These engineers have the highest employability ratio. Civil has lower amongst all courses due to less practical exposure of students [2]. There is a need to focus on industrial internships and training of the students.

Considering the scenario of higher technical education, as per the reports discussed above, there is high time to analyze the education system and find industry connections to improve the employability of students. Two parameters which are in discussion – industry and technical institutes are the centers of discussion in this paper. The industries are achieving excellence and moving towards world-class, whereas there is a question of survival for the education system. The reason for industrial excellence is the implementation of Total Productive Maintenance (TPM). The problem for employability is industry connection and lack of skills due to which students are unemployable. The paper aims to connect the TPM concept in the education sector to enhance the quality of technical institutes resulting in increasing the class of graduating students. The TPM discussed in brief, and the Total Productive Education model thus proposed in the paper for technical education.

2 Total Productive Maintenance

In industries, the parameter to measure output is in terms of productivity. To increase productivity, they focus on reducing losses at every stage, governed by various pillars of TPM. They reduce the losses to improve the performance of machines, process and motivates and train the workforce. TPM is the tool for effectively minimizing losses in production, machine downtime, material scraps for improving the working efficiency, the productivity of employees, and equipment [4].

Key elements by which TPM is characterized:

1. TPM aims to maximize equipment effectiveness and efficiency.
2. TPM establishes a system of Preventive Maintenance (PM) for the machines over their lifespan.

3. TPM is cross-functional, implemented by various departments (operations, engineering, maintenance management, and administration).
4. TPM involves every single employee, from senior management to operators and clerical staff, to develop small group activities, emphasizes the role of teamwork.
5. To achieve zero losses, no accidents, no defects, and no failures [4, 5].

TPM is governed by its eight pillars, with the base of 5S. Implementing 5S is the preparatory stage for TPM. 5S is a valuable and critical element of the TPM process. It is challenging to assess the economic value of the 5S activity, as they are not a result center. They emphasize people's behavioral patterns, such as cleaning and neatening of equipment, the elimination of unnecessary items from the workplace. Subsequently, the activities are making it difficult for the quantitative assessment of their effectiveness. However, it is possible to do evaluations qualitatively. Several checklists are available for such checking on a macro scale. If 5S not taken seriously, it leads to 5D. They are Defects, Delays, Dissatisfied customers, Declining profit rate, and Demoralized employees [6]. 5S implemented and monitored at each pillar of the TPM helps to improve productivity and thus, improves OEE.

The 5S and TPM are from Japanese culture. These Japanese words in 5S are – Seri, Seiton, Seiso, Saketsu, Shitsuke [7] described in Table 1:

The study shows that 5S implementation in the industries has the following implications [7]:

- Commitment to improvement from all employees.
- Proper use of spare parts with a reduction in mistakes.
- Reduction of breakdowns.
- Quick and easy accessibility of the maintenance tools.
- Reduction of maintenance costs.
- Pleasant and safe working place.

TPM Pillars: There are eight pillars in TPM. TPM pillars aim to reduce major and minor losses, thus improving OEE. The pillars of TPM has the task to

Table 1 5S Description

5S Steps	Description
Seiri (Sort)	Have a place for each item. Sort and remove unwanted items.
Sieton (Set in order)	Put each item in its place.
Seiso (Shine)	Clean and maintain the workplace daily.
Seiketsu (Standardize)	Standardize the procedure for the first three S, and follow it.
Shitsuke (Sustain)	Sustain the process by the following self-discipline.

reduce the assigned losses and improve efficiency. The TPM pillars described as follows:

Pillar 1: JH- Jishu Hozen (Autonomous Maintenance): is the mother pillar amongst all. It aims to bring the ownership approach to the operator. The operator owns the responsibility of cleaning and maintenance of his machine.

Pillar 2: KK – Kobestu Kaizen (Focused Improvement): aims to identify and minimize waste and manufacturing losses. Eliminate losses resulting in improving OEE.

Pillar 3: PM – Progressive Maintenance: pillar deals with Preventive break down (Time Base Maintenance). It establishes Preventative and Predictive Maintenance systems for equipment and tooling. Thus, minimizing breakdown losses and other main losses.

Pillar 4: ET (Education and Training): boost the morale and expertise of the operators and persons involved by providing soft skill training and technical training.

Pillar 5: QM (Quality Maintenance): pillar monitors the factors affecting variance in product quality. It focuses on zero quality defects.

Pillar 6: IFM (Initial Flow Management): establish systems to shorten new product or equipment development prototyping lead time. Achieve stable commissioning of new product and equipment vertical start-up.

Pillar 7: OTPM (Office TPM): the goal is to create a highly efficient office, achieve zero functional losses, and provide effective service and support to other departments. Administrative and support departments are treated as process plants, performing tasks to collect, process, and distribute information.

Pillar 8: EHS (Environment Health and Safety): Assures safety and prevents adverse environmental impacts, which are important priorities in any TPM effort. EHS achieves and sustains zero accidents, creates a healthy, rewarding, and pleasant workplace [8]. Figure 2 shows the TPM house with base 5S and eight pillars.

The elementary measure associated with Total Productive Maintenance (TPM) is the OEE. The OEE highlights the actual hidden capacity in an organization [6], depending on three parameters: – Availability of machine/equipment, performance, and quality. It takes into consideration the six major losses, named as [9]: Downtime Loss, Breakdown loss, Setup and

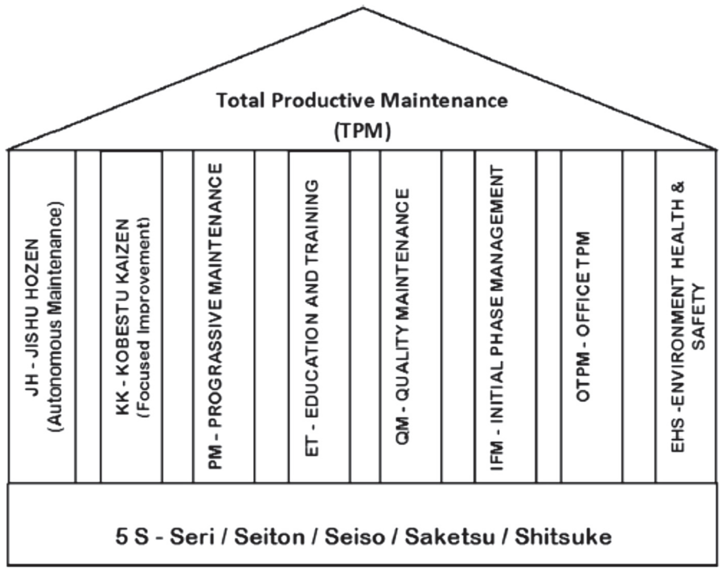


Figure 2 TPM pillars.

adjustment time losses, Speed Loss, Performance loss, Defect, or quality losses. TPM pillars also function to reduce other losses along with these six losses. These losses can be reduced/eliminated by using various techniques in the form of TPM tools. TPM tools are procedures, methods, and activities performed and monitored during the deployment of TPM. Some of the tools deployed to analyze and solve equipment and process-related problems include but not limited to the following, shown in Table 2 [7]:

The above tools are used for eliminating the losses and for increasing the performance, thus improving the OEE.

OEE calculated as the product of the three main bases for the six major losses:

1. Availability indicates the problem caused by downtime losses.
2. Performance indicates the losses caused by speed losses
3. Quality indicates scrap and reworks losses [10].

All the above parameters have individual formulas to calculate the term. If the industry achieves OEE more than 85%, it is marching towards excellence [11].

Table 2 TPM tools

S. No.	TPM Tool	Description
1	2-Bin System	It is an inventory control system. There are two bins –a working bin and a supporting bin. When the first bin has been consumed, the material from the second bin is transferred, and the order is placed, maintaining sufficient stock.
2	5 Why's	It is a process to determine the root cause of a problem. In this technique, a series of questions like why something occurred, then why this happened, asked and repeated until the root cause is identified.
3	5S	5S is the first step implemented in TPM, which focuses on cleaning, organizing, and maintaining the workplace.
4	AQL Acceptance Quality Limit	AQL is a statistical tool to limit the number of defective items acceptable in a randomly selected sample.
5	Benchmarking	Benchmarking is the process of comparing and setting the best practices in an organization.
6	Bottleneck Analysis	The bottleneck is the analysis tool to identify the critical and blocking step in the process, which affects continuity inflow, acting as a constraint.
7	Brainstorming	It's a problem-solving technique involving team members from all sections. Generate and provide better solutions to the problem.
8	Cause and Effect (Fishbone) diagram	It is a root cause analysis tool to identify the causes and their effects on the process. It resembles a fishbone structure.
9	Cross-Training	It is a training process to make the workforce compatible to handle another process within work, in case of an emergency.
10	CUDBAS	Curriculum Development Based on Vocational Ability Structure It is the recent tool used for the education and training of the workforce.
11	FMEA	Failure Modes and Effects Analysis It is the process of analyzing failures and their effects.
12	Gemba	It is a problem identifying technique by visiting at actual workplace.
13	Kaizen	It is an activity by an individual or a team for continuous incremental improvement in the organization.

(*Continued*)

Table 2 Continued

S. No.	TPM Tool	Description
14	Pareto chart	It is for showing the frequency of occurrence.
15	Poka Yoke	It is a mechanism to make the process error-proof. It prevents mistakes from becoming defects.
16	Preventive Maintenance	It is for regular maintenance to avoid failure.

The basic equations for the calculations are given below [7]:

$$\text{OEE (in \%)} = \text{Availability (A)} \times \text{Performance efficiency (P)} \times \text{Quality Rate (Q)}$$

$$\text{Equipment availablility (A)} = \frac{\text{loading time} - \text{down time}}{\text{loading time}} \times 100$$

$$\text{Performance efficiency (P)} = \frac{\text{processed amount} \times \text{Cycle time}}{\text{operating time}} \times 100$$

$$\text{Quality Rate (Q)} = \frac{\text{processed amount} - \text{defect amount}}{\text{processed amount}} \times 100$$

The OEE is a proven approach and a powerful tool used to perform diagnostics as well as to compare production units in different industries. OEE is used to evaluate the most bottleneck operation or machine in an organization. The OEE not only helps to achieve minimum breakdown and to keep the plant in a good working condition at the lowest possible cost but also reveals the hidden costs associated with the efficiency of the equipment [12].

Benefits of implementing TPM:

- Productivity and overall plant efficiency increases from 1.5 to 2 times
- Manufacturing cost reduces up to 30 %
- Reduction in accidents
- Identification & resolve customer complaints
- Pollution control measures taken care
- Improvement in product quality
- Increases consistency
- Creates ownership feeling in employees and Increases confidence level
- The workplace is always neat, clean, and attractive
- Change in attitude of the operators in favor of the company
- Sharing of knowledge and experiences among all
- Teamwork to achieve organizational goals
- Horizontal deployment of a new concept in all areas of the organization [4].

TPM successfully implemented in many industries, and the results are excellent. Case studies show the improvement of OEE by TPM. Sutoni A. et.al. discussed TPM analysis on lathe machines using the OEE method [13] through the case study conducted in an automobile base Lathe machine. The analysis of the Lathe machine was done over a year. The root cause analysis is done with by Fishbone diagram method. The problems and losses were identified and resolved, which increased OEE due to reduction of losses as:

- Setup and Adjustment losses reduced by 40.3%,
- Reduced Speed Losses by 19.9%,
- Breakdown Loss by 18.5%,
- Idling Minor Stoppage by 17.6%,
- Rework Loss by 3.8%, and Scrap or Yield Loss of 0%.

Zarreti et al. gave the recent case study of cybersecurity concern for TPM in a smart manufacturing system [14]. Paper represents how the TPM and then ultimately, OEE can be affected by the attack of threats on the system, which have interconnectivity of cyber and physical domain in a smart manufacturing system. For the prevention of this, IT security is required to avoid downtime of the system.

Meca Vital et al., in their survey-based study, discussed the TPM and impact of each pillar in the OEE [15]. In the case study, the analysis of the impact of each TPM pillar on the Overall Equipment Effectiveness (OEE) metric is presented. The study is survey-based. The results showed that the Focused Improvement, and Planned Maintenance pillars were implemented in most of the respondent companies. The paper gives the idea regarding the sequence of implementation of the TPM pillars for various sectors.

S. Nallusamy described an increase in the efficiency and productivity of the CNC machine using TPM [16]. The case study is to study the effectiveness and implementation of the TPM and 5S in a machine shop for enhancing OEE. It focused on minimizing the breakdowns, increase the performance and quality rate of the machine, thus improving the effectiveness. The outcome was OEE improvement by 5% in the horizontal machining center and by 7% in the vertical machining center. S. Nallusamy also presented a case study for the manufacturing industry [17]. Reflecting the OEE increment by 15%, achieved by the reduction in setup time, cycle time, rework time, and breakdown losses.

TPM implementation in industries is discussed with the case studies, success stories, and analysis by many authors. Considering the benefit of TPM, a similar concept thus proposed to be implemented in the education sector to increase efficacy. The TPM pillars are focusing on reducing or eliminating the losses. In the technical education system, the problems identified and methods to address these problems are suggested, based on the TPM concept, the Total Productive Education (TPE) model proposed in the paper, for the higher technical education sector.

3 TPM in Education Institutes

3.1 Input and Output

The earlier sections describe the TPM and its benefits. Effective implementation of the TPM concept from industry in the education sector is possible according to the analogy proposed. In industry, the manufacturing process involving man and machines, convert the raw material to finished product. Whereas, in education institutes, students at particular grades upgraded to higher qualifications with the teaching-learning process. Figure 3 shows the analogy between the industry and institute.

The raw material is input for the industry. Whereas, for the institute, it is students of different levels. The manufacturing process in the industry, replaced by the teaching-learning process in institutes. A finished product from industry analogous to the student at an upgraded level and degree institute. Problems in education institutes correlated to losses in industries affecting productivity, and attempt to propose the tools to eliminate problems.

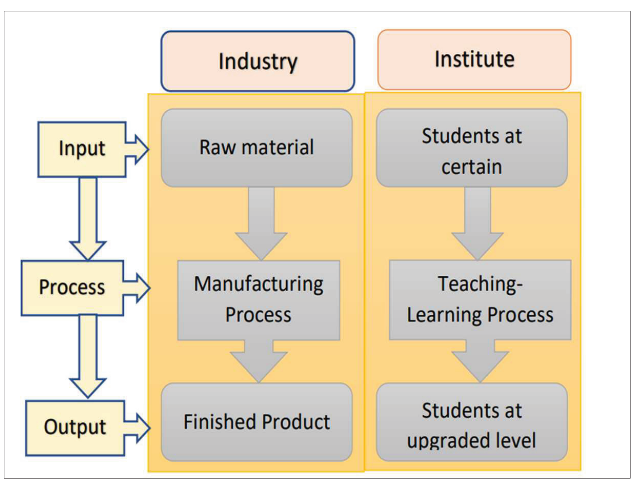


Figure 3 Input-output for industry and institute.

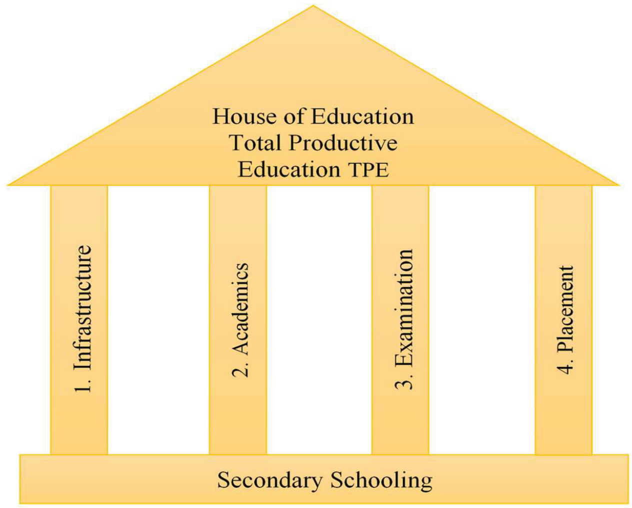


Figure 4 TPE Pillars.

3.2 Comparing Losses in Industry and Problems in Institutes

TPM reduces sixteen major losses and improves overall equipment effectiveness and efficiency. The losses compared with problems in institutes.

The problem in institutions are identified in terms of sixteen losses in industries as given in Table 3:

4 Total Productive Education

The above section discusses TPM, its pillars, tools applied for reduction of losses are also listed and explains OEE. The Total Productive Education (TPE) model for the education system is proposed on a similar basis. Education institutes have four major stakeholders – Students, Faculties, Employers (industries), and Society (Parents, friends, colleagues, relatives, etc.). Considering the interest of stakeholders four pillars are recommended for TPE in the education sector. Figure 4 shows the TPE pillar structure.

The house of higher technical education has four pillars with the base of students with grades 10 and 10+2 (for Indian scenario for diploma and bachelor's degrees). The input quality of the students also affects the entire system and efficiency of the institutes. Depending on the merit quality of students' pre-requisite bridge courses can be suggested.

Table 3 Industrial losses and Institute problems

16 Major Losses in Industry	Problems in Institute
1. Setup and Adjustment	• Late admission of few students, change in a course/program, change in Institute/University.
2. Start-Up	• Students admitted to a particular course are not having the necessary prerequisite, weak in basic fundamental principles, language problems. • Students are not interested but are forced to take admission to a program they are not interested in. • Students are failing in exams in the first attempt.
3. Operating Motion	• Avoid delay in movement from laboratories, workshop, seminar hall, canteen with proper layout of the departments.
4. Line Organization	• The dependency of departments – exam department needs timely support from faculties from submission of question bank/question paper to assessment of answer sheets. • Store – to provide Stationary requirements for the department, students printed journals, consumable material for laboratory purposes like chemicals, petrol/diesel.
5. Management	• Administration, delay in the process of admission/ form filling/ banking. • Process for each department: admissions, student section, accounts, exams, departments, training and placement, transport, canteen. • Delay from management in terms of operations and funding, the timely decision in the procurement of workforce, and equipment.
6. Equipment Failures	• Inadequate infrastructure to conduct theory classes and insufficient laboratory equipment to perform laboratory work. • Conduction of practicals is affected by the failure of laboratory equipment, machinery breakdown. • Classroom teaching is affected by the failure of teaching aids like LCD projectors, computers, internet. • Transportation is affected by bus failure. • Canteen – non-availability of raw material, vegetables, cooking gas. • Office – Failure of ERP, internet, telephone lines, etc.

(*Continued*)

Table 3 Continued

16 Major Losses in Industry	Problems in Institute
7. Measurement and Adjustment	• Assessment of Staff – Appraisal to be done. • Wrong evaluation of students' in examination
8. Minor Stops	• Less Attendance of students, Loss of lectures due to non-attainment of staff/student, holidays, strikes.
9. Reduced Speed	• Slow delivery of contents by the teacher. • More time is taken for learning and completion of the assignments by slow learners. • The syllabus coverage is not as per the teaching plan.
10. Defect and Rework	• Failure of students. • Extra or remedial lectures for the absent or fail students.
11. Scheduled Down Time	• Holidays, Preparation leaves, vacations.
12. Yield	• Scholarships, discounts are given to students. • Increase in the overhead cost of faculty and infrastructure due to cancellation of admission, non-recovery of fees, fewer admissions than proposed intake.
13. Energy	• Identify the loss of energy in electric power, fuel, water, air.
14. Tool Die and Jig	• Equipment related loss due to laboratory equipment, its maintenance, depreciation, replacement of old computers, teaching aids like LCD projectors, smartboards.
15. Cutting Blade (Tool) Change	• Laboratory set up for machine equipment to perform practical.
16. Logistics	• Material loading unloading at the workshop/laboratory.

Four pillars proposed for the TPE model are discussed in brief along with the TPM tools to be implemented for various TPE pillars.

1. **Infrastructure:**
   Infrastructure for education institute consists of the land, buildings, laboratories, library (books, magazines & other related things), smart classrooms, facilities like canteen, transportation, hostels, playground,

etc. Along with all these amenities, the institute should provide well-qualified faculties. Infrastructure is considered as the first pillar of TPM as it is necessary to have the set up to start the institute. Provision for future expansions in terms of land, building, and additional amenities needed along with the initial setup. The use of the TPM tools will help in this regard. Few tools are discussed herewith but are not to be limited. TPM tools used in the infrastructure pillar are as follows:

i. **5-S – the** 5-S system for cleaning, organizing, and maintaining a work area – classroom, library, laboratories, workshop, etc. to maximize efficiency and consistency.
ii. **Kaizen –** Promote kaizens for improvement and maintenance of infrastructure and effective utilization of the available resources.
iii. **CLIT –** Maintenance of laboratory and workshop equipment.

The tools discussed above gives the typical application related to infrastructure. In this regard, proper scheduling, execution, and monitoring system with different charts and plans are required for the implementation of the TPM concept. Implement TPM pillar – Initial Flow Management (IFM) for infrastructure planning.

2. **Academics**

Academics are the heart of the education system, consists of teaching the learning process, curriculum design, industry-institute interactions, research and publication, skill enhancement of the students, preparing students industry-ready. Academic pillars can focus on students, teachers, and the teaching-learning process. Curriculum design and update of the syllabus will be the base for the Academic Pillar. It is necessary to deploy an effective teaching-learning methodology for the proper delivery of the contents. Outcome-Based Education (OBE), Project-Based Learning (PBL), Activity-based learning (ABL), and recent teaching-learning methodologies to be adopted, thus enhancing learning outcomes. Implement the proper ratio of theoretical and practical content. While executing these various TPM tools can be used to increase efficacy.

TPM tools used in the Academics pillar are as follows:

i. **Benchmarking –** Referring to best practices from successful organizations to improve overall academic performance.
ii. **Brainstorming –** For curriculum design involving expertise with diverse experience from academics and industry.

iii. **Gemba –** Visit a workshop and laboratory to identify problems for conduction. Visit classrooms/ laboratories to observe the theory and practical delivery.
iv. **Kaizen –** Continous improvement in the teaching-learning process example -upgrade the teaching process with ICT.
v. **CUDBAS –** Curriculum Development Based on Vocational Ability Structure.

These are the few amongst TPM tools related to academics. Evaluating the performance of staff and students' other TPM tools like Check sheets, Control charts, AQl is possible.

3. Examination

Examination performs the assessment and evaluation of students' knowledge and skills. It is one of the significant departments, and the success of the university depends on the effective working of this department. Mode and conduction of examination are chief elements, failure of which results in degraded results/output and drop out of the students from the course.

Essential points in the examination to be considered are the exam pattern, assessment/marking scheme, supplementary exam, and result declaration. Reassessment may require after the declaration of result, as per students' demand like after-sales service in the industry.

TPM tools used in the Examination pillar are as follows:

i. **Kaizen –** Promote kaizens for improvement of the exam process.
ii. **2 – Bin System** – Proper inventory management for exam stationery and other material required.
iii. **Poka-Yoke** – Setup an error-free procedure for online and offline exams.

4. Placements

Placement reflects the effectiveness of the institution. Student placement is the outcome of the education system. The number of enrollment depends on the placement ratio of the university. If the students are getting jobs with a handsome package, admissions will increase, attracting more meritorious students. It enhances the quality of students in the university, thus making teaching-learning more effective.

TPM tools suggested for the Placement pillar are as follows:

i. **5 Why's –** Implemented to find the cause of deprived employment ratio.

ii. **AQL –** Improve the quality of students to make them employable.
iii. **Benchmarking –** Goal for more placements with good incentive packages.
iv. **Brainstorming –** Brainstorm with a focus to increase the number of placements and attract respectable industries for campus placement of students.
v. **Cross-Training –** Provide students with multi-skills. Prepare staff for multi-tasking.

Few tools are suggested for placements but are not limited. The education and Training pillar of TPM can be taken as a reference for the execution of the placement pillar.

5 Case Study – Implementation of TPE Model at Sandip University, Nashik

Using tools from Preventive Maintenance to identify the problems in the education institute. For illustration, a fishbone diagram shows students' problems analysis [18]. Figure 5 shows the fishbone diagram considering students as the analysis point.

Figure 5 demonstrates the fishbone diagram for student problem as cause to be analyzed so represented as the head of the fish. The problem may be personal, related to the university, resources available, or academics. These

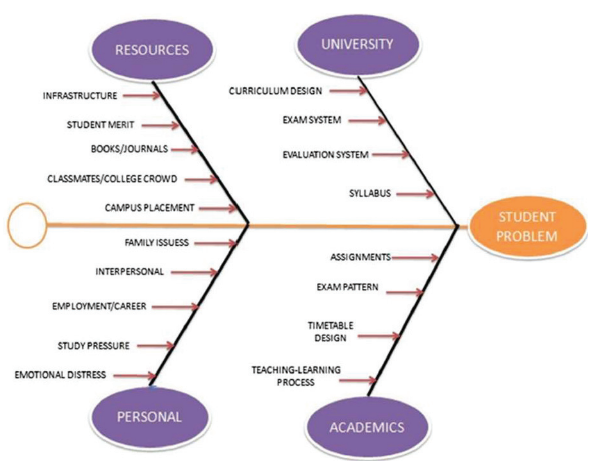


Figure 5 Fishbone diagram for identifying the root cause of students problem.

areas identified form the wings of the fish. Further, for each problem, the cause is detected, and sub-branching is done, as the skeleton of fish. The solution is proposed based on the problem identified.

Sandip University, Nashik, Maharashtra, India, practices a few of the techniques of the proposed Total Productive Education.

A case study to identify the problems faced by students, and staff, was taken at Sandip University, Nashik. Students and staff problems identified are analyzed, and TPM tools are used o rectify them.

The problems identified from the root cause analysis of students identified the areas focused on in the education section. Problems faced by the students are categorized into seven headings mentioned below [19]:

1. Academics
2. Industrial visits/seminars/workshops/events
3. Research and development
4. Psychological problems of students
5. Infrastructure/ Sports
6. Financial
7. Placements

Each characteristic is dealt with in detail and the TPE tools are proposed.

1. Academics:

Academics is the foremost concern of students' interest. The problem highlighted the teaching-learning process. Students are interested in practicals and industrial exposure than theoretical delivery. Experiential learning, as a solution, was implemented in a few courses.

For the course engineering graphics, students find it confusing to imagine the concept. As a part of experiential learning, small projects assigned related to specific topics, and students performed the group task to complete their projects.

Figure 6 shows the model prepared by the students for the course engineering graphics. Figures 6A and 6B explains the concepts of the development of solids for prism and pyramid. Development of the surfaces marked on the sheet, cut at the outline, and folded to get solid objects. Figure 6C shows a triangular pyramid and cube developed by the students. It helped the students to understand the concept as they have prepared it themselves. Similar to the application of sheet metal cutting is also cleared with this. A prepared solid model is used to imagine the projection of solids as their new topic. Figure 6D demonstrates the concept of projections of Lines. Instead of

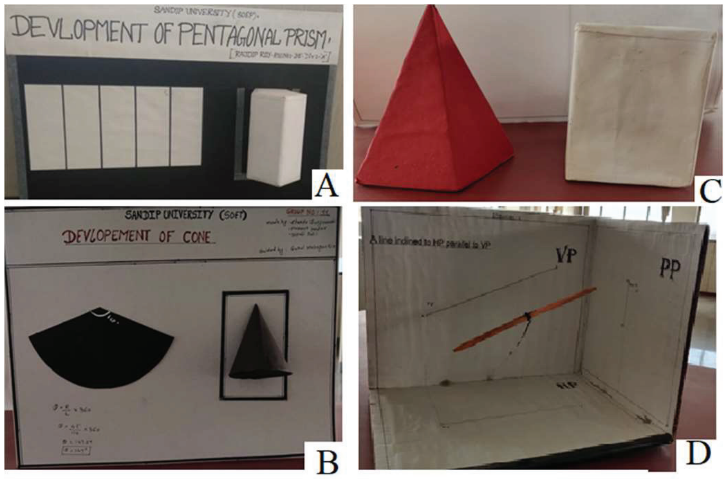


Figure 6 Models for Course Engineering Graphics.

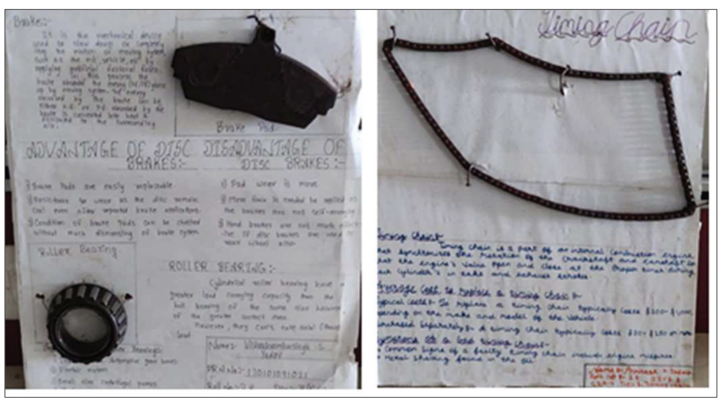


Figure 7 Assignment for Theory of Machine.

imagination, they can see the line in a different position and project it as per requirement.

For the course theory of machines, students' were assigned to describe the component by explaining it with the help of a real object, as shown in Figure 7.

To study different mechanisms, students prepared mini working projects of the same as shown in Figure 8.

Figure 8 shows the models of the Oldhams coupling, Oscillating cylinder, Screw jack, and Geneva mechanism. Similarly, other models are prepared and

Figure 8 Mechanisms for course Theory of Machine.

Figure 9 Experiment setup for course Heat Transfer.

presented by the students, which makes it easy to understand the working and application of the same.

Students' group are assigned projects related to experiments to perform for a particular topic. Figure 9 shows the experimental setup prepared for the course Heat Transfer to find the emissivity of the test material.

Figure 10 shows the setup prepared by students for the synthesis of a four-bar mechanism.

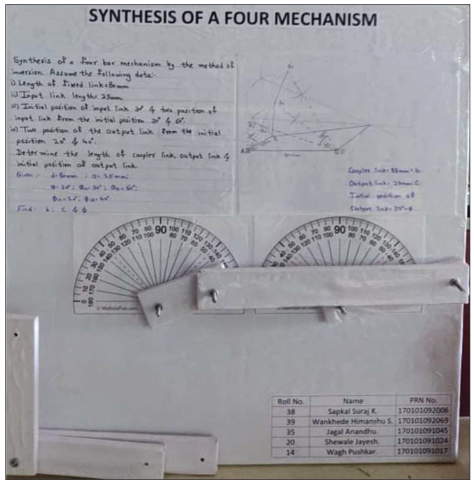


Figure 10 Experiment setup for course Theory of Machines.

In addition to this, mobile learning, project-based learning, activity-based learning is proposed [20]. In Sandip University, Outcome-Based Education (OBE) is implemented and practiced.

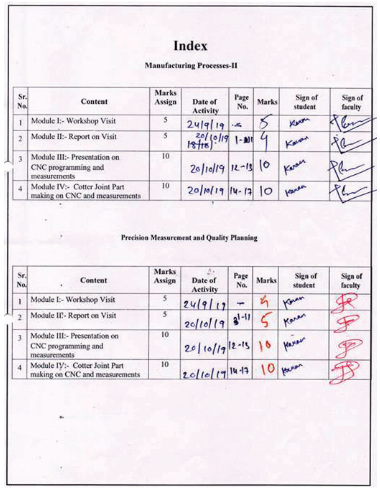
2. Industry/ workshop visit

Figure 11 shows the experimental learning performed for the subject manufacturing process, which also covers the industrial visit/workshop requirement of the students. Thus, giving practical exposure to the students to the equipment as they are studying and using them to perform the practicals in the workshop. The students visit the industry/workshop/site where they experience the working environment. They submit the report regarding their visit. Then they present the study and conclusion drawn from the visit. They are also given hands-on practice for computer-related topics.

Figure 12 shows some content from the experiential learning report of the course. The equipment/measuring instruments taught in the course manufacturing process/ metallurgy are used by the students while performing practices in the laboratory/workshop. It gives in-depth knowledge regarding the device to the students.

3. Research and Innovation

The guidance provided to inculcate the research culture and develop a habit of writing and presenting research articles. Seed funding provided to do presentations and projects. The technical competitions are organized for



Index

Manufacturing Processes-II

Sr. No.	Content	Marks Assign	Date of Activity	Page No.	Marks	Sign of student	Sign of faculty
1	Module I:- Workshop Visit	5	24/9/19	-	5	Karan	[illegible]
2	Module II:- Report on Visit	5	~~18/10~~ 20/10/19	1-[illegible]	4	Karan	[illegible]
3	Module III:- Presentation on CNC programming and measurements	10	20/10/19	12-13	10	Karan	[illegible]
4	Module IV:- Cotter Joint Part making on CNC and measurements	10	20/10/19	14-17	10	Karan	[illegible]

Precision Measurement and Quality Planning

Sr. No.	Content	Marks Assign	Date of Activity	Page No.	Marks	Sign of student	Sign of faculty
1	Module I:- Workshop Visit	5	24/9/19	-	4	Karan	[illegible]
2	Module II:- Report on Visit	5	20/10/19	[illegible]1-11	5	Karan	[illegible]
3	Module III:- Presentation on CNC programming and measurements	10	20/10/19	12-13	10	Karan	[illegible]
4	Module IV:- Cotter Joint Part making on CNC and measurements	10	20/10/19	14-17	10	Karan	[illegible]

Figure 11 Index for Experiential learning for Manufacturing Process course.

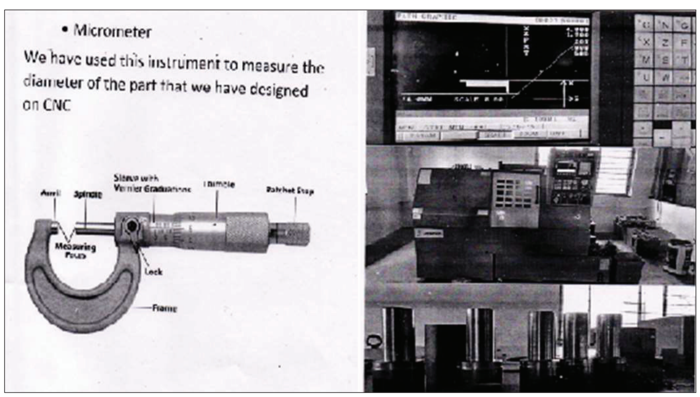


Figure 12 Contents of the report of the above index.

exploring the research among students. They are given exposure to the new emerging technologies by arranging expert lecture series regarding the topics related to curriculum and other than the curriculum.

4. Psychological problems of students

To address the psychological problems of the students' counselor's need to be appointed. They come from different cultures and financial conditions. Many times they need personal counseling. Students to be engaged in extra and co-curricular activities, sports, and competitions.

Figure 13 Students performing Yoga.

At Sandip University, students are having a Yoga and meditation session [21]. It helps the students to keep their mental peace. Figure 13 shows students performing yoga at Sandip University.

For enriching the interest of the students as per their hobby, various clubs formed like music, cycling, dance, drama, movie photography, where students get engaged. It helps in stress-relieving.

5. Infrastructure/ Sports

Other than academics, playgrounds and sports facilities are made available to the students. Various sports events' are held to keep the students physically and mentally fit. It enhances the efficiency of the students and institutes as well.

6. Financial

Various scholarships attract meritorious students. The input quality of students affects the placement ratio of the institute. Along with merit, other scholarships like sports scholarships, scholarships for financially weaker students to be given.

7. Placements

Placement is the output parameter of the students. Students trained for multidisciplinary work by organizing workshops for improving communication skills, presentation skills, personality development of the students.

TPE pillars proposed and tools proposed to enhance the productivity of the education system was practiced in Sandip Unversity, established in 2016 with the regular pattern. The implementation of TPE started with the 5S tool. Outcome-based education implemented for academics since the academic year 2017. The results improved progressively. Infrastructural changes were also suggested and implemented for effective utilization of the classrooms, seminar halls, library, etc. The campus is 250 acres, having various buildings at different locations at long distances. Instead of the central library, shifted to separate buildings, as per the convenience of students to avoid the time loss and monitoring. Instead of two canteens, five canteens at different locations are made operational. The implementation shows positive results and improvement in the performance of the students and staff.

6 Conclusion

The TPM effectively implemented in industry improves OEE, and the industries March towards world-class excellence. The TPE model proposed in the paper and the results of its implementations show the effectiveness of TPE in the education sector. Various tools used for increasing productivity in the industry works well for institutes. 5S implemented at the department level helps to keep the workplace intact and assessable. TPM tools like Kaizen's and Poka-Yoke helps to improve departments, avoids errors in systems, examinations, and other departments. Outcome-based education enhances the academic performance of the students. TPE pillars will help to build a system like TPM and its tools for the education system. TPE system in term will be the system to enhance productivity in the higher technical education system.

7 Future Scope

The paper proposes a TPE model for the education system based on TPM in industry. Taking a case study at Sandip University, Nashik, some of the implementations also discussed. However, the following scope for further research in this field is possible.

1. Four primary pillars are proposed and discussed in the study. There is scope for others as per the requirements.
2. Limited TPM tools are suggested in this paper for the implementation of TPE. The use of other TPM tools is possible for increasing the efficacy of TPE.

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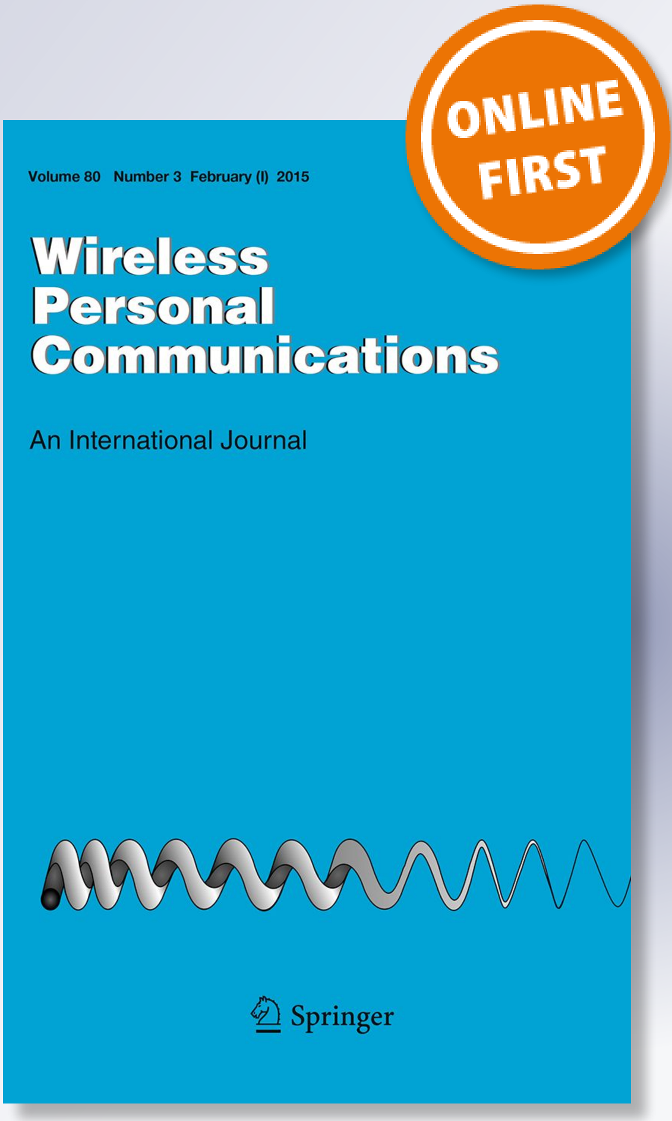

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Application of AHP for Ranking of Total Productive Maintenance Pillars

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Abstract Total Productive Maintenance—TPM is widely being used in industries for manufacturing excellence. TPM is based on its eight pillars. Successful Implementation of TPM from its kick-off to final stage depends on in-depth knowledge of these pillars. The purpose of the paper is to rank eight pillars of TPM according to their importance with respect to four parameters: Productivity, Cost, Quality and Delivery in Time, by using Analytic Hierarchy Process (AHP) a multiple criteria decision-making methodology. A pairwise comparison of TPM pillars is done by use of AHP method, by considering a case of automotive industries in India. Ranking of TPM pillars is proposed to set guidelines to decide the weightage of each pillar in terms of major factors to improve Overall Equipment Efficiency. This in terms will guide management to give proper preference and allocate fund at proper time to proper pillar. The ranking suggested suites for automotive sector and assembly lines. By varying the judgmental rating the new ranking can be obtained from the suggested guidelines on similar basis.

Keywords Analytical hierarchy process (AHP) · Total productive maintenance (TPM) · TPM pillars · Ranking

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1 Introduction

In today's competitive world, it is a great challenge for industries to achieve World class excellence. To cope up with the globalized economy, manufacturers are facing stiff competition. It is a tedious task to produce maximum with minimal resources and finances available, with eminent quality and timely deliverance. Proper production planning and timely maintenance with zero defects can cause the system pull through. Proper implementation of Total Productive Maintenance (TPM) will lead the industries towards manufacturing excellence.

TPM is based on eight pillars with the foundation of 5S (Sort, Set in order, Shine, Standardize, and Sustain) [1]. It is not an easy task to understand and implement TPM, as if a set of standard procedures which, when implemented will give the results [2]. TPM is widely used to improve effective use of equipment's and to obtain world class manufacturing system in terms of Quality and Cost [3]. Successful implementation of the TPM is a team work in which individuals from each and every department should work together, it is employee focused. Due to experience and expertise operator knows more about his machine and process. Managers and maintenance team as per their experience can judge the tasks to be done or the processes to be eliminated. They can try for different alternatives to make the equipment and process more effective [4]. Nevertheless, the decision is considered by top management. It is the way how the managers prove the significance of the task in terms of the cost involved and the expected outcome of it, they based on their experience can fix up the priorities.

In most of the case studies, barriers in implementing TPM are discussed. It is reflected that successful implementation of TPM is difficult without the support of top management. Financial constraints are more important as per the management is concerned. If management is convinced properly, then the major hurdle in the TPM implementation will be taken away. To merge the gap it is needed to present the analytical approach, to formulate a quantitate analysis of the TPM process to focus on the most important pillar. Top management can lead discussions as per budgetary provision or can allot extra fund for TPM implementation. Detailed review of the Industries shows that only some of the areas are being focused. Survey in Indian industries reflects the limitations of TPM implementation. It is mainly due to lack of knowledge and fear of investments in terms of returns. The main reason identified is that the implementation of TPM is experienced based having theoretical approach.

Considering all these factors, it is important to identify the priority of the TPM pillar analytically so that the management is convinced to implement the changes step by step and monitor the returns and see the improvement in OEE to make the industry to achieve world class excellence [5].

This paper thus proposes ranking of the eight TPM pillars, as per their significance in terms of four major parameters productivity, cost, quality and delivery in time (PCQD). A pairwise comparison is done showing their hierarchy, by using Analytic hierarchy process (AHP). AHP makes it possible to assess the criteria's based on the experience [6]. The ranking of pillars made in hierarchical order makes it easy to focus on the particular task of comparatively higher priority and the judgmental forecast can be done with saving plans. As per hierarchy of pillars, priority can be given to the critical maintenance activities, with optimum use of the resources, which will increase Overall Equipment Efficiency (OEE).

2 Literature Review

TPM plays vital role in making the industry world class, measured by Overall Equipment Efficiency (OEE). TPM kick-off is done in many industries but very few are able to successfully implement it. To the best of author's knowledge, most of the literature discusses the failures due to improper implementations of the TPM. Review of TPM implementation in the Indian Service sector shows a tendency of people react to implement new things, approach of top management to curb down the budget for several activities, problem of purchase and replacement of material, visionary approach and management support, are some of the factors bearing on effective implementation of TPM in Indian industries [5].

Significant review of TPM implementation in Indian industries is addressed by Bon and Lim [7], Narender and Gupta [8], Ahuja and Khamba [9], Gupta and Vardhan [10]. TPM initiatives in steel plant, highlights how TPM implementation improved the production facilities in terms of four major criteria's—Productivity, Quality, Cost and Delivery in Time. In typical Indian industry, holistic approach for TPM needs to be implemented successfully. Team work, motivation and continuous improvement are necessary factors for positive results. In today's competitive world, Indian industries need to have proactive strategic initiatives to lead the organization to world class standards. TPM factors are analyzed by exploring need, factors and challenges of TPM, pointing out the obstacles for effectively implementing TPM in Indian industries.

It is discerned that Indian industries are facing challenges because of many reasons like—sluggish response to change with the current market scenarios, traditional organizational structure, low quality and productivity, lacking in employee skill, education, motivation and safety, low automation, more wastage, failure to delivery in time, costumer complaints, taxes and infrastructural lacunas. According to Attri et al. [5] barriers to implementation of TPM in Indian industry can be classified as: Behavioral, Technical, Human and Cultural, Strategic and operational. Whereas Ahuja and Khamba [4] has classified the barriers as: (1) Organization—inability to change managerial and cultural approach, inability to convince unions, wrong focus on TPM, improper communication from top to bottom, (2) Cultural—resistance to change traditional approach, lack of consistency, (3) Behavioral—resistance from employees to adopt new changes, (4) Technological—little effort to improve design, reliability, lack of training and skills, (5) Operational—acceptance of high rejection, lack of implementing standard procedures, absence of planned maintenance, (6) Financial—additional fund required in beginning to implement TPM, financial constraints from top management. (7) Departmental—poor team work.

For successful implementation of TPM it is important to find proper hierarchy of TPM pillars with respect to QCDP.

This can be done through pairwise comparison by Multi Criteria Decision Method (MCDM). Martin et al. [11] summarized various MCDM methods with its application. AHP suits for ranking the pillars, as pairwise comparison between the pillars with respect to the criteria's can be easily done. Lot of improvements are been done through TPM in Indian industries by using AHP. But only the importance of TPM verses Traditional maintenance system (TMS) is analyzed [12]. Similar attempts are being made by other researchers to justify TQM by using AHP [13]. Proper application of AHP or any other analytical method for hierarchy of TPM pillar is missing.

Use of AHP is found in various Production/manufacturing applications, Buyurgan and Saygin [14] presented a framework in advanced manufacturing, Madu [2] implemented it for improving maintenance float system. Ishizaka and Labib [15] described its use for process ordering method. This technique is applied in many areas social, personal, education, engineering, manufacturing, banking, sports, government [16] and many more fields and showed good results. No attempt has been made to use it for TPM. Attempt has been made to rank the TPM pillars by using AHP.

3 Background

Brief regarding the TPM pillars and AHP process is given herewith:

3.1 TPM Pillars: Abbreviations Used

TPM pillars and abbreviations used are shown in Fig. 1.

TPM is based on eight pillars with a base of 5S. The goal of 5S is to create a clean and well-organized work environment.

Pillar 1: JH is mother pillar. It brings the ownership approach in the operator. Cleaning and maintenance is taken care by the operator himself.

Pillar 2: KK aims to identify and minimize waste, quality and manufacturing losses. Elimination of losses helps improving OEE.

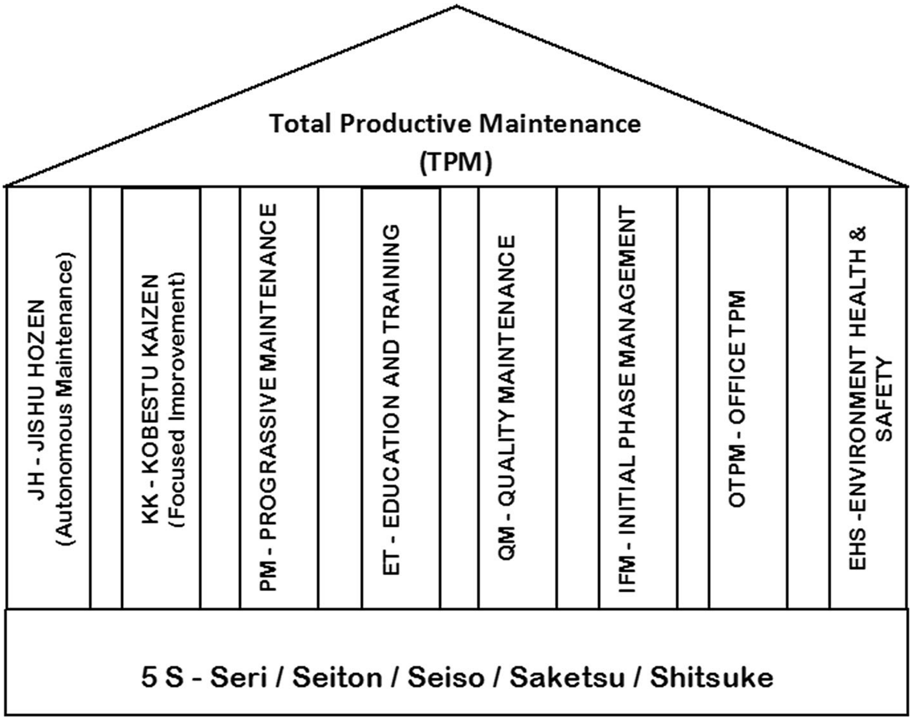

Fig. 1 TPM pillars

Pillar 3: PM pillar deals with Preventive break down (Time Base Maintenance). It establish Preventative and Predictive Maintenance systems for equipment and tooling. Effectiveness of maintenance department is increased to the point where 8 big losses are not generated.
Pillar 4: ET boost the moral and expertise of the operators and persons involved by to providing soft skill training and technical training.
Pillar 5: QM pillar monitors the factors affecting variability in product quality. It focus to accomplish zero quality defects.
Pillar 6: IFC establish systems to shorten new product or equipment development prototyping lead time. Achieve stable commissioning of new product and equipment vertical start up.
Pillar 7: OTPM goal is to achieve zero functional losses, create highly efficient offices and provide effective service and support to other departments. Administrative and support departments can be seen as process plants whose principal tasks are to collect, process, and distribute information. Process analysis should be applied to streamline information flow.
Pillar 8: SHE Assures safety and prevents adverse environmental impacts which are important priorities in any TPM effort. EHS achieve and sustain zero accidents, creates healthy, rewarding and pleasant workplace.

3.2 Analytic Hierarchy Process

Analytic Hierarchy Process (AHP) was developed by Saaty [6]. It is used for multi criteria decision making in which the factors are arranged in a hierarchic structure. An advantage of the AHP over other MCDM methods is that AHP is designed to incorporate tangible as well as intangible factors, especially where the subjective judgments of different individuals constitute an important part of the decision process.

A pairwise comparison method is used to calculate relative values between each TPM pillar with respect to each other for four criteria's QCDP. A scale of judgments ranging from 1 to 9 (equal to extreme) is used for rating.

The methodology of AHP consists of following steps [17]:

Step 1: Statement of Problem having Attributes and Criteria.
Step 2: Represent problem in form of tree.
Step 3: Pairwise comparison of alternatives.
Step 4 Formation of square matrix of above comparison.
Step 5: Normalization matrix is formed from eigenvalues and eigenvectors (weights).
Step 6: Check Consistency of the matrix by calculating the Consistency Index, CI. The value of CI should be less than 0.1 as recommended by Saaty.
Step 7: Obtain local and global ratings.
Step 8: Priorities or overall goal.

4 Objective

The objective of the research paper is to rank TPM pillars in terms of their importance in contributing to the factors of Industrial excellence like Quality, Cost, Delivery in time and Productivity (QCDP) using AHP developed by Saaty [6] for the excellence of Indian industries. Pairwise comparison of each pillar considering each criteria is done. Influence of Moral and Safety is equal with respect to each pillars, there contribution is not significant as compared to other criteria's. So focus is made on PCQD.

This research is based on providing the best possible solution with an analytical approach to the present theoretical concept of TPM. The study focuses on Indian industries where the TPM is not effectively implemented. During the survey for ranking of the pillars, it was clear that the TPM kick off takes place, but it is not implemented properly and over a period of time it stops. Failure occurs due to one or more constraints and barriers as discussed. The main reason is involvement of management and availability of fund for implementing the things at right time in right place. If the management is convinced for proper grading of the pillars it will be easy to allocate the fund at proper time. Ranking will give the proper focus and set the priorities for the budget. Successful implementation of TPM helps to improve OEE.

5 Methodology

A survey was conducted based on the questioner using 9 point rating scale of Saaty for AHP [6]. Companies from Automobile and assembly sectors were considered for the survey. Following points were considered while selecting the company for survey:

a. The industry should have 5S culture, ensuring environmental cleanliness, safety and comfort. Thus the role of the criteria's Safety and Moral shall not be reckoned in determining hierarchy based on QCPD.
b. This will be more rational if the Industry happens to be an engineering Industry of Assembly type instead of a Process plant where dust and contamination of air, water etc. is dominant.

5.1 Collection of Data

Analysis is based on the data collected from Indian industries. During implementation of TPM, scheduling and implementation of various pillar activities is to be done. As will be noted, the pillar activities had to be considered in great detail and the work had to be done at a MICRO LEVEL for each pillar. There is one master schedule involving all the pillars. In addition, each pillar has its own activity break up and time scaled chart of its own. As a part of research methodology the paired comparison data is collected in consultation with the management representatives of some companies or other persons responsible for TPM implementation. The management representatives have overall responsibility of TPM planning and implementation and they are appointed by the CEO of the company. Apart from them, consult of various pillar heads of the industry are taken to make the data more authentic. Each of these pillar heads is an experienced senior manager aware of all the pillars and their impact on Quality, Cost, Delivery and Productivity (QCDP). A 9 point rating scale for AHP2 is used for rating the contribution of pillars with respect to each other for different criteria's PCQD.

5.2 Ranking of TPM Pillars

Analytical Approach A study of literature on TPM reveals that most of reported information describes the eight pillars in a QUALITATIVE manner without resorting to utilize mathematical modelling. Most of the literature available gives an account of how a certain industry applied TPM and achieved increased productivity, quality, etc. at reduced cost. It is almost a monotonous repetition of the eight pillars. There is a need to make a proper attempt to rank the pillars in a QUANTITATIVE way so as to be a helpful guideline for research into Total Productive Maintenance. In the research work to be carried the following points are considered for pillar ranking:

a. Use of Analytical Hierarchy Process: Analysis has to be carried out by using paired comparison of each of the eight pillars with the objectives: Quality, Cost, Delivery on time and Productivity. The paired comparison helps in calculating the relative score of each of the TPM pillars on the four criteria. Next the four criteria are compared with each other through paired comparison to find the weightage of each of the criteria. Finally, on multiplying the scores of the eight TPM pillars, the summed, weighted score of these pillars is calculated. This helps in identifying the most important pillar on the overall ranking.
b. It is to be determined what is the contribution made by each pillar to the four attributes QCDP. Finally, a ranking will be done about the total contribution made by each pillar towards making the industry in question, a World Class Company.

This technique is used for many computer applications and many more fields and showed good results. No attempt has been made to use it for TPM.

5.3 Analytic Hierarchy Process

For the objective to rank eight pillars of TPM with respect to their importance towards QCPD, AHP process is used to find the hierarchy of the pillars as follows:

5.3.1 Criteria and Attributes

For ranking of the TPM pillars, its eight pillars are criteria's and Quality, Cost, Delivery in time and Productivity (QCDP) are considered as attributes.

5.3.2 Hierarchy of Decision

The hierarchy of the attributes and criteria are shown in Fig. 2.

5.3.3 Pairwise Comparison Scale

Scale for AHP: Standard 9 point rating scale proposed by Saaty [18] is used for rating the pillars.

5.3.4 Pairwise Comparison Matrix

A questioner was generated to rate the pillars with respect to each other, sample shown in Table 1. Nine point Linker scale is used for rating the pillars with respect to each other.

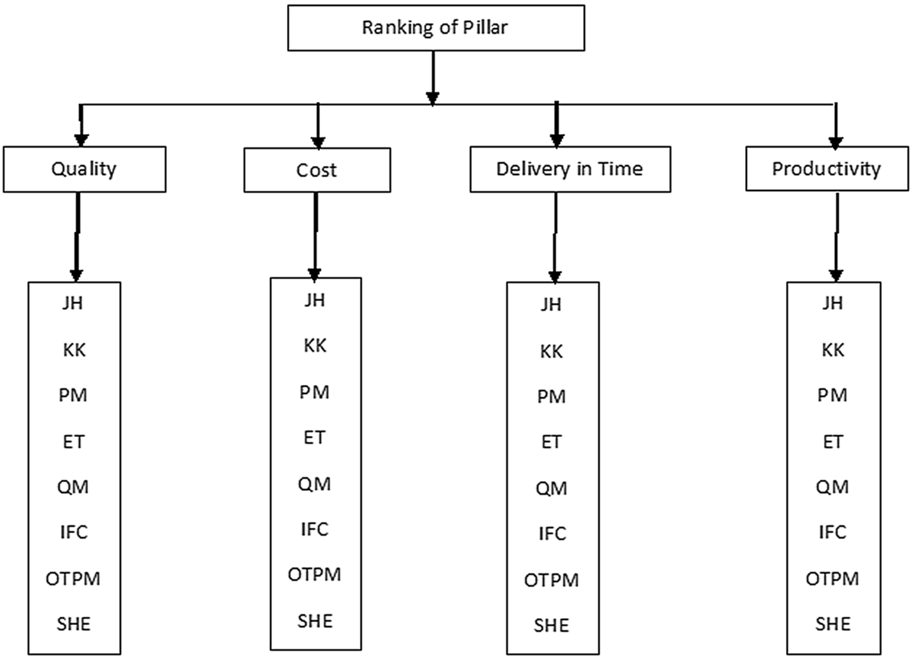

Fig. 2 Hierarchy of decision

Table 1 Sample values from questioner

Factor	Factor weighting score-quality																	Factor
	More important than								Equal	Less important than								
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	PM
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM

Table 2 Criteria quality: pair-wise comparison

	JH	KK	PM	ET	QM	IFC	OTPM	SHE
JH	1.00	6.00	1.00	4.00	1.00	6.00	8.00	8.00
KK	0.17	1.00	0.50	0.50	0.50	1.00	6.00	8.00
PM	1.00	2.00	1.00	4.00	0.50	6.00	8.00	8.00
ET	0.25	2.00	0.25	1.00	0.50	6.00	8.00	8.00
QM	1.00	2.00	2.00	2.00	1.00	8.00	8.00	8.00
IFC	0.17	1.00	0.17	0.17	0.13	1.00	1.00	4.00
OTPM	0.13	0.17	0.13	0.13	0.13	1.00	1.00	4.00
SHE	0.13	0.13	0.13	0.13	0.13	0.25	0.25	1.00

Based on the ratings given a pairwise comparison matrix is prepared for each criteria. Table 2 shows rating of various pillars considering Quality as the criteria.

Similarly, based on the data from questionner, matrix are obtained for other criteria. Tables 3, 4, and 5 shows rating for Cost, Delivery in time and Productivity respectively.

5.3.5 Normalization

Table 6 gives the calculations for normalization matrix for various pillars with respect to Quality as a criteria.

Normalization matrix for other criteria can be obtained similarly.

5.3.6 Consistency Check

Saaty [18] proposed that the consistency index should be less than 10%, if not the priorities does not make any sense and the judgments may need to be revised for various pillars with respect to Quality as a criteria. Consistency check is conducted after normalization matrix.

Table 7 shows the Consistency check for the above normalization results. Saaty [18] proposed that the consistency index should be less than 10%, if not the priorities does not make any sense and the judgments may need to be revised for various pillars with respect to Quality as a criteria.

Saaty has proposed consistency index (CI), which is related to Eigen value as given by Eq. (1) [19].

$$\mathrm{CI} = \frac{\lambda_{\max} - n}{n - 1}, \tag{1}$$

where n = dimension of the matrix, $\lambda_{\max}$ = maximal eigenvalue.

The consistency ratio, is given by Eq. (2):

$$\mathrm{CR} = \mathrm{CI}/\mathrm{RI} \tag{2}$$

where RI is the random index, selected from the values given in Table 6, "RI is the average CI of 500 randomly filled matrices" [19].

Table 7 shows the Consistency check for the above normalization results.

As consistency ratio CR is less than 10% the matrix can be considered as having an acceptable consistency.

Similarly weightage are found for Cost, Delivery in time and Productivity.

Table 3 Criteria cost: pairwise comparison

	JH	KK	PM	ET	QM	IFC	OTPM	SHE
JH	1.00	1.00	1.00	4.00	1.00	4.00	0.50	4.00
KK	1.00	1.00	1.00	6.00	1.00	6.00	1.00	6.00
PM	1.00	1.00	1.00	6.00	1.00	6.00	1.00	6.00
ET	0.25	0.17	0.17	1.00	1.00	1.00	0.50	1.00
QM	1.00	1.00	1.00	1.00	1.00	4.00	1.00	6.00
IFC	0.25	0.17	0.17	1.00	0.25	1.00	0.50	4.00
OTPM	2.00	1.00	1.00	2.00	1.00	2.00	1.00	8.00
SHE	0.25	0.17	0.17	1.00	0.17	0.25	0.13	1.00

Table 4 Criteria delivery in time: pairwise comparison

	JH	KK	PM	ET	QM	IFC	OTPM	SHE
JH	1.00	2.00	1.00	4.00	1.00	8.00	6.00	4.00
KK	0.50	1.00	4.00	6.00	4.00	8.00	6.00	6.00
PM	1.00	0.25	1.00	4.00	1.00	8.00	6.00	6.00
ET	0.25	0.17	0.25	1.00	0.50	6.00	4.00	4.00
QM	1.00	0.25	1.00	2.00	1.00	8.00	6.00	6.00
IFC	0.13	0.13	0.13	0.17	0.13	1.00	0.50	0.50
OTPM	0.17	0.17	0.17	0.25	0.17	2.00	1.00	4.00
SHE	0.25	0.17	0.17	0.25	0.17	2.00	0.25	1.00

Table 5 Criteria productivity: pairwise comparison

	JH	KK	PM	ET	QM	IFC	OTPM	SHE
JH	1.00	2.00	1.00	4.00	1.00	8.00	6.00	4.00
KK	0.50	1.00	4.00	6.00	4.00	8.00	6.00	6.00
PM	1.00	0.25	1.00	4.00	1.00	8.00	6.00	6.00
ET	0.25	0.17	0.25	1.00	0.50	6.00	4.00	4.00
QM	1.00	0.25	1.00	2.00	1.00	8.00	6.00	6.00
IFC	0.13	0.13	0.13	0.17	0.13	1.00	0.50	0.50
OTPM	0.17	0.17	0.17	0.25	0.17	2.00	1.00	4.00
SHE	0.25	0.17	0.17	0.25	0.17	2.00	0.25	1.00

Table 6 Criteria quality: normalization matrix

	JH	KK	PM	ET	QM	IFC	OTPM	SHE
JH	0.261	0.420	0.194	0.336	0.258	0.205	0.199	0.163
KK	0.043	0.070	0.097	0.042	0.129	0.034	0.149	0.163
PM	0.261	0.140	0.194	0.336	0.129	0.205	0.199	0.163
ET	0.065	0.140	0.048	0.084	0.129	0.205	0.199	0.163
QM	0.261	0.140	0.387	0.168	0.258	0.274	0.199	0.163
IFC	0.043	0.070	0.032	0.014	0.032	0.034	0.025	0.082
OTPM	0.033	0.012	0.024	0.010	0.032	0.034	0.025	0.082
SHE	0.033	0.009	0.024	0.010	0.032	0.009	0.006	0.020

5.3.7 Ratings

After comparing all the pillars with respect to different criteria's, the criteria's are also compared with respect to each as per the priority. Weightage for QCDP are tabulated below. The comparison matrix for QCDP is in Table 8.

Table 7 Criteria quality: consistency check

	Weights	Products	Ratio
JH	0.2544	2.3963	9.4196
KK	0.0910	0.7891	8.6750
PM	0.2033	1.9168	9.4296
ET	0.1292	1.1859	9.1787
QM	0.2312	2.0604	8.9131
IFC	0.0416	0.3625	8.7180
OTPM	0.0315	0.2622	8.3282
SHE	0.0179	0.1498	8.3547
		CI = 0.1253	
		CI/RI = 0.09	

Table 8 Pairwise comparison of QCDP

	Q	C	D	P
Q	1.00	4.00	2.00	1.00
C	0.25	1.00	0.50	0.17
D	0.50	2.00	1.00	0.50
P	1.00	6.0	2.00	1.00

6 Results and Discussion

Finally the percentage weightage are calculated in Table 9. The graphical representation of the hierarchy obtained by AHP is shown in Fig. 3. Where % ranking is shown on Y—Axis verses Pillars on X-Axis.

In case of TPM implemented industries it can be seen that out of eight pillars JH and KK are used more number of times than other six. JH & KK pillars has the maximum weightage, with marginable difference. JH focus on improvement of Quality which enhances productivity whereas KK has high impact on Productivity by reducing various losses, increased production rate maintaining prompt delivery schedule followed by reduction in manufacturing cost. It is recommended to start implementing TPM with JH pillar followed by KK. After that the focus on PM & QM pillars. Once all these are in

Table 9 Score of the pillars as per hierarchy

Pillar	% Weightage				Overall (%)
	Q	C	D	P	
JH	25.44	15.18	11.44	21.43	20.581
KK	9.10	19.15	22.29	28.73	19.903
PM	20.33	19.15	19.31	16.92	18.722
ET	12.92	5.71	10.50	8.14	10.048
QM	23.12	15.28	13.96	15.51	17.899
IFC	4.16	5.29	5.82	1.96	3.682
OTPM	3.15	17.36	13.84	4.29	6.620
SHE	1.79	2.87	2.84	3.03	2.545

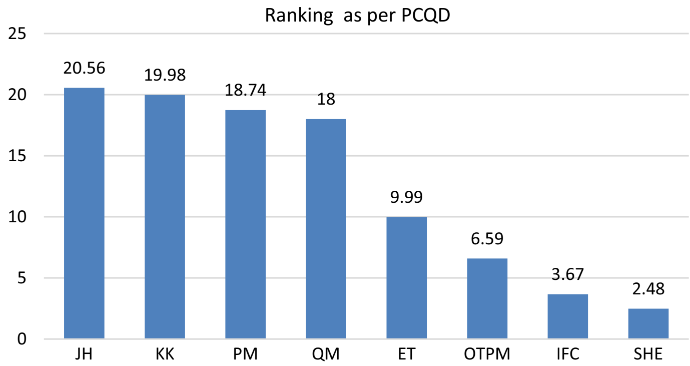

Fig. 3 Ranking of TPM pillars as per contribution towards criterias PCQD

action, it will be enhanced with ET & OTPM pillar activities. IFC and SHE can be followed thereafter.

6.1 Constraints

It has to be noted that the hierarchy achieved is applicable to a certain type of industry set and should not be taken as universal. For example:

1. Pillar Safety, Health and Environment, though important to an engineering industry, it is far more important to a process or Chemical Industry. So during pairwise comparison matrix these pillars are given more weightage with respect to others.
2. Pillar Office TPM is vital for service type organizations, though it is also needed for speeding up supply chains in production type organization. So accordingly these pillars will carry more weightage with respect to others in service industry but will be of less importance in Chemical or process industries.
3. Pillar Autonomous Maintenance which is regarded most important one. Autonomous Maintenance or Jishu Hozen is the heart of TPM and an operator is his own machine keeper. But these pillar will comparatively have less importance in service industry. Accordingly the hierarchy will change.
4. Focused Important as a pillar is dedicated to minimizing losses. It calls for great creativity to eliminate all kinds of losses. 16 losses are listed by the Japanese Institute of Plant Maintenance. In service industry this pillar will be of low importance.

The Constraints can be overcome by proper grading of the pillars with respect to each other in AHP—during pairwise comparison matrix as explained in Sect. 5.3.3 above with example in Table 1. The constraints can be totally addressed by proper grading the pillars by experts. To overcome the constraints the committee of experts in all areas (design, manufacturing, production, maintenance, office, etc.) during implementation of TPM are required. The proper ranking of the pillars can be obtained if the pairwise comparison is given by panel of experts.

7 Conclusion and Future Scope

The results obtained helps to categorize the pillars according to priority as: top priority (JH and KK), medium (PM and QM) and low priority (ET, OTPM, IFC and SHE). It will be easy for the managers to convince the top management and attract attention on the pillars with top most priority. However the results obtained will work for particular set of companies, it should not be treated as universal. The survey results are for automobile components manufacturing industries. According to the type of industries the rating can be varied and the new hierarchy can be obtained easily. For chemical industry top priority may go to pillar SHE, whereas for service industries it may be OTPM.

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Fishbone Diagram: Application to Identify the Root Causes of Student–Staff Problems in Technical Education

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Fishbone Diagram: Application to Identify the Root Causes of Student–Staff Problems in Technical Education

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Abstract Fishbone diagram, also called as 'cause-and-effect' diagram, is a tool used to identify the root cause of problems which represents the effect and the factors or causes influencing it. The tool is a template for brainstorming possible causes of an effect. As there could be infinite causes, this helps in identifying the root cause/s in a structured and precise way. An attempt has been made in this paper to use this technique to identify problems in the engineering education system in India, considering student and staff as the stakeholder. Major problems are classified and Fishbone diagram is used to analyse the root causes focusing on select parameters like personnel, academics, resources and universities. By identifying the causes, feasible solutions are suggested for improvement. A detailed analysis of student-staff problems is done by taking the case study of engineering institutes in general. The solutions suggested particularly are implemented in Sandip University Nashik.

Keywords Fishbone diagram · Root cause analysis · Engineering education system · Students–staff problems · Outcome based education (OBE) · Sandip University

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1 Introduction

The current imbroglio in the teaching–learning process consists of three major stakeholders namely; staff, students and society. In the present scenario, every stakeholder plays an equivalent role in the success or failure of a system. Thus, focusing on two of the stakeholders (i.e. students–staff), this paper aims to understand the root cause of problems. It deals with the problems arising in the life of student–staff in the present technical education system. Analysis of the problems is done with the help of 'cause-and-effect' diagram.

This method proves to be effective in order to reach the root cause of any issue. In this process, there are major parameters namely; personal, academics, resources and university, which act as key points. The sub-issues will be further analysed.

The outcomes, after identifying the problems concerning student–staff, will be analysed and the major areas will be brought to the limelight. In this way, we will be able to propose a common solution to the problems and also the methods will be discussed to overcome them. Furthermore, this paper makes an effort to mitigate the flaws in the engineering education system in India to increase its efficiency and strengthen its position in the global education scenario.

2 Literature Review

2.1 Scenario of Indian Engineering Education System

In the Indian education system there are three variables:—Sanctioned intake, Enrollment and the Output or Out-turn. These are defined as follows:

(a) Sanctioned Intake—It is for engineering institutes approved by All India Council of Technical Education (AICTE) for different engineering colleges in each state. This is for a given year.
(b) Enrollment—The actual number enrolled (joining the course). It may differ from the sanctioned strength as in many institutions (all seats may not be filled).
(c) Outturn/Output—The numbers that graduate each year [1].

As per annual report 2015–16 of All India Survey on Higher Education (AISHE), highest number of students are enrolled in Arts/Humanities/Social Sciences—109.4 lakh, followed by 43.8 lakh in Science and 42.5 lakh to Engineering and Technology [2].

However, it is observed that the percentage of out-turn from engineering and technology is very less. So, a special focus is made to highlight the challenges for Technical Education in India.

According to Prof. Rao and Singh, there is need to create a real partnership between Educator, Industry and Government. Public–Private partnership and Institution–Industry interface should be augmented [3]. The engineers graduating should be ready for industry i.e. they should possess skills, interpersonal skills, team work, goal setting, leadership, motivation, self-esteem and creative thinking [4]. Major areas to be focused upon to sustain Indian Education System are: Quality of Education, Affordability of Education and Ethics in Education [5].

Mohanty and Dash in their paper focused on the same issues, concluding that Indian technical education should follow Washington Accord. Apprenticeship training is must to enhance skills in students [6].

Similarly, Waghmare et al. [7] and Singh [8] highlighted on the above mentioned issues and suggested some additional reforms like High-tech library, stipend to research scholars, fair quality assurance system and examination reforms [7, 8].

Gupta suggested three steps to correct the current scenario of Indian technical education. First, the Industries should extend financial and managerial support. Second, vocational subjects at + 2 level should be made compulsory to enhance skills in students. Third, promote partnership between public–private sectors and NGO's along with increase in apprenticeship training [9].

Higher Education in India is to be strengthened because India has the opportunity to become a prominent R&D (Research and Development) destination. The Indian government is implementing initiatives to boost R&D. On the contrary, Global companies are spending increasing amount on R&D [10].

The block diagram shown in Fig. 1 describes the Indian engineering education system and its stakeholders. The prime factors are the inputs (students, faculty, infrastructure and funds), linkages (society and industry), and outputs (education, research and entrepreneurs or placements) [1].

Engineering education is a professional technical degree of 4-years. After graduation, outcomes are higher education, research, placement or entrepreneur. However, according to the latest survey of AISHE [2], very few students have pursued higher education and enrolled for research as compared to other streams. Also employability ratio of engineering graduates is comparatively less.

In the light of the above mentioned factors, it is mandatory to brainstorm the reasons for poor output of engineering education. This study incorporates all such lacunae which have deterred the quality of graduates who are either not competent or are unskilled for employability. The analysis done here will be focusing on the input parameters namely student–staff.

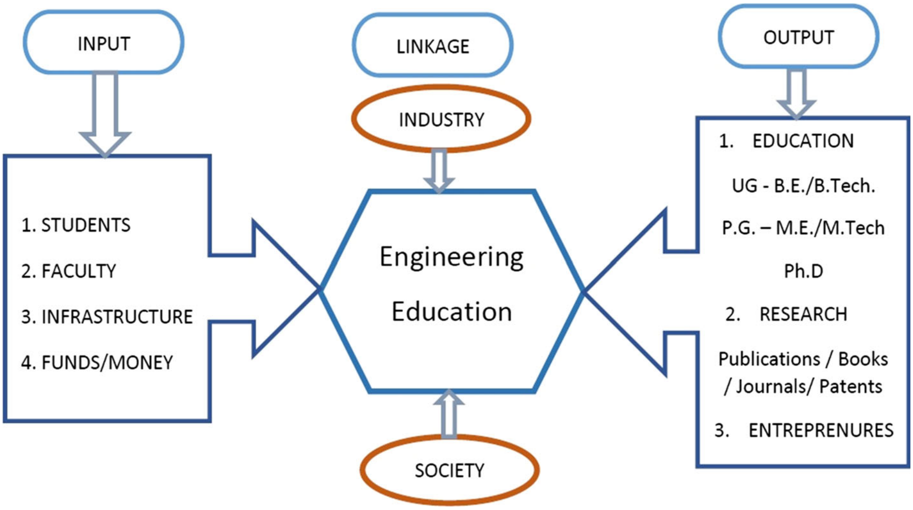

Fig. 1 Engineering education in India—Stake holders

2.2 Fishbone Diagram

The Ishikawa diagram is a tool to recognize the root causes of quality imbroglios. It was named after Kaoru Ishikawa, a Japanese quality control statistician, the man who pioneered the use of this chart in the 1960s. The Fishbone diagram is a process of breaking down the known truths that provide an orderly way of observing result and the reason that accounts for those effects. Because of the intention of the Fishbone diagram, it may be delegated as a cause-and-effect diagram by Watson in 2004. Fishbone (Ishikawa) diagrams mainly represent a model of suggestive presentation for the correlations between an event (effect) and its multiple causes. The structure provided by the diagrams helps team members think in a very systematic way [11].

Fishbone diagram is effectively used to reach the root cause of the problem. Some of the cases are discussed herewith. Jayswal et al. have used this to analyse sustainable process of chemical/energy sector [12]. Quantification of risk assessment for FMEA analyses is in processing industry [13].

Use of Fishbone in Educational sector is reflected in few cases. Reid [14] used this for categorizing barriers of instructional technologies. Jih and Huang [15] used it for analysis of e-teaching. Use of 5-why technique for questioning technique was done in Taiwan by Lu [16]. Problems with university and colleges where analyzed by Desai et al. [17]. However, the analysis is to be done in Indian perspective.

3 Stakeholders in Technical Education System

Following are the major stakeholders in Indian Education System:

1. Students
2. Faculties
3. Infrastructure
4. Parents
5. Industries/Employees
6. Government—State/Central

Out of these, two parameters namely; Student and staff are considered for analysis.

A detailed analysis has been carried out by taking a case study of Sandip Foundation, Nashik. Personal interviews and feedback are taken from engineering students and faculties of various branches for B.E. (Undergraduate level) Program in Engineering Institutes on the campus. The points are discussed in detail by applying Fishbone diagram for root cause analysis.

4 Fishbone Diagram: Student Problems

Figure 2 shows the root cause analysis of the student problems with the help of fishbone diagram. The main reasons are personal, universities, resources and academics. These main factors have sub-factors which take us to the root cause of these problems.

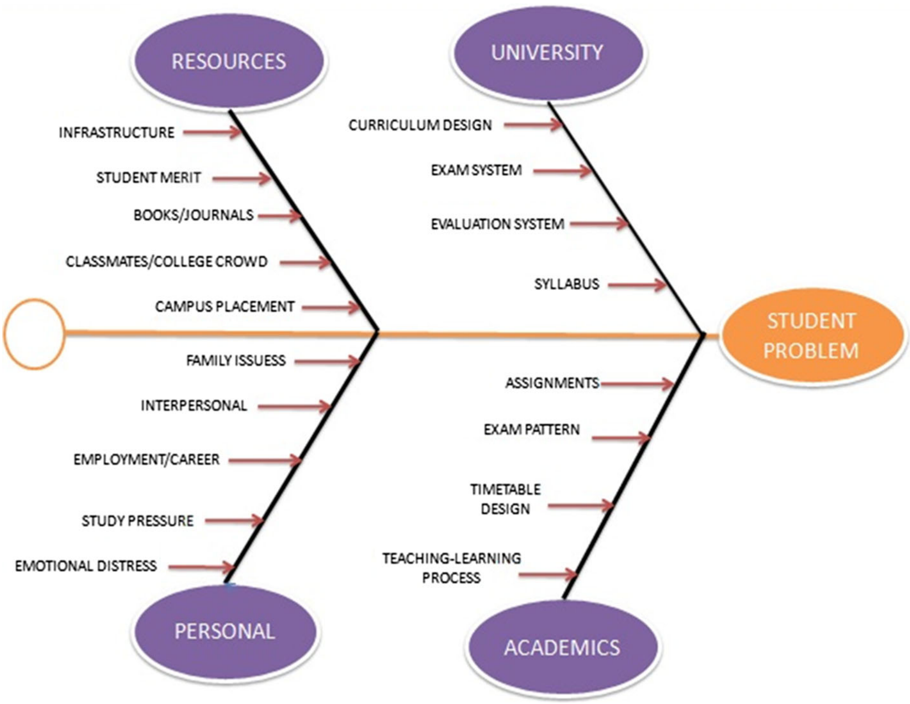

Fig. 2 Root cause analysis of students problems

4.1 Personal

Zhibin Chen, in his paper, reveals Psychological Problems and countermeasures of college students, all the personal and psychological problems which the college students face. On further adaptation, the paper reveals that nowadays it is a major issue in college life to have these problems and many students are diagnosed with these disorders. The author jotted down few causes for these emotional unbalance in a student's mind. They were as follows: interpersonal tensions, crises of employment and career prospectus, study pressure, emotional distress, psychological expectations do not meet family, contemporary social impacts, inertia in inherent traditional educational models, family reasons and traditional Chinese cultural factors. The above mentioned causes are relevant and do exist in the life of students [18].

One more parameter that is to be considered is that there are no proper career counselors available for guiding the students in their journey to become a successful engineer.

According to Lie Pan, Haiyan WU and Xun Wang, career counselors say that access to information is the key to employment. There are various mediums to seek information like campus network, University Career Guidance Website, Job network, customized services etc. According to the authors, students are keen to work and get employed but the only issue is they do not have the right platform to do so. They lack information and the seriousness of employment in the colleges while getting educated. Colleges should increase the propaganda of employability right from the first year [19]. There are many suicidal causes of students observed in India due to increasing mental stress and lack of proper guidance.

4.2 Academics

The reasons that come under the student problems in relation to academics are as follows:

1. Assignments
2. Exam pattern
3. Timetable design
4. Teaching and learning process.

Considering each pattern separately, we get to know that higher technical education demands various assessments to test a set of skills of a student on problem solving skills, logic abilities, etc. The candidate has to solve these assignments and prove his worth in every assignment in order to get good grades in the term work and face his exams. These assignments also reflect the student's capabilities to understand the topic. The assignments should be designed in such a way that they are fair enough to test skills but not intimidate the student. However, according to Ramesh and Rao, many a times home assignments are not taken seriously by students and a lot of copying is involved thus making it unfair to grade their work [20].

Students opine that, they have an issue with assignments when excessive assignments are forced on them. To the point assignments which will reflect their abilities are considerable, although just writing for the sake of assignments, does no good. In engineering education, excessive assignments play a key role in consuming the time of the student. However, a good assignment, if replaced with these unnecessary works, will definitely help to improve the scenario of Indian engineering education. For this, it is necessary to have different techniques to get the things done in a more practical way, which can be done by Problem Based Learning (PBL), Activity Based Learning (ABL), Case Based Learning (CBL).

Continuous Internal Assessments (CIA) should be done following Outcome based education system (OBE). Secondly, exam pattern is a very prime issue in understanding the difficulty to get good grades in the exam. Every student's perception of getting adapted to the education system is different and also the estimated time for getting adjusted with the system may differ. This difference often results into the failure or a major setback for the student. Understanding the exam pattern is very important in order to write the exams. In Indian universities, over the time, many patterns have changed which confuse the students to a larger extent. Students take time to understand exam pattern, which results in their gradation. They focus on scoring in exams but miss the actual concept. Thirdly, timetables play a crucial role in any academic system. A well-designed timetable is always a key to more success stories in engineering education. Time-table can be for exams as well as for daily scheduled lectures. Academic timetable should take care of basic workload as per the university guidelines, as well as of co-curricular and extra-curricular activities of the students. It should as well consider the time required for student upgrading and merging the gap between syllabi and present requirements from the recruiters. Both the timetables should be designed in such a way that they take care of all norms but are also student friendly, that are designed by making student as the prime focus considering their study and work. Lastly, another very important factor is the teaching–learning methods. Latest techniques of teaching–learning should be used like: PBL, ABL, CBL, e-Learning, ICT etc. in Indian education system. Traditional teaching methods should be supplemented with these recent techniques for excellent results.

The students should be made aware of the opportunities available for Job, entrepreneurship and also interest should be created for further studies and Research.

4.3 Resources

As material is required in industries, resources are required for education. One of the causes for student failure is resources. This cause highlights various shortcomings as: college infrastructure, variation in students merit, books, journals etc.

The college infrastructure plays a vital role in the education of students, if it is not well-built than there will be obstacles to the overall development of the student. Some of the most basic necessary elements that a college should have are: well-equipped classrooms and laboratories, as the norms mentioned by the university and regulating authorities like University Grant Commission (UGC) and All India Council of Technical Education (AICTE). Library with sufficient books, journals, newspapers, magazines, e-library with access to online books and journals prove to be important aids in education.

Classmates/colleagues are also major reason for the student to be disinterested in the curriculum. If the intake quality of students is not good or students are not study oriented, they affect the performance of the other student as they might distract the student's focus from studies and divert it elsewhere. This may happen if there is big difference in students merit during enrollment.

Campus placement also plays a major role. Also access to industries through industrial visits, expert lecture series through industrial person, in-plant training, internship and projects are required for overall growth of students. Some colleges fail to do so, which negates the moral of students.

4.4 Universities

Role of universities is very important because the entire educational course is governed by it. Curriculum Design is the most important parameter. Examination system and evaluation system also affect the output of students. It should be taken care to match the syllabus with latest technologies. The system should be student-centric.

After considering the four factors of the student problems, an attempt has been made to identify the causes affecting these parameters. The causes mentioned are as per the authors view, keeping in mind the technical education and may differ as per the application.

5 Fishbone Diagram: Faculty Problems

Figure 3 shows the root cause analysis of the Faculty problems with the help of fishbone diagram. The main reasons are personal, universities, resources and academics. These major factors have sub-factors which take us to the root cause of these problems.

5.1 Personal

The personal issues like family background and responsibilities play major role in stability of the faculty. The faculty should be financially well-supported to work freely without any stress. The emotional quotient of the faculty also affects the work performance. The faculty should be mentally prepared to take up additionally allotted task given from time to time. The faculty should be eager to learn new things and implement it for effective teaching. S/he should be highly motivated for his profession.

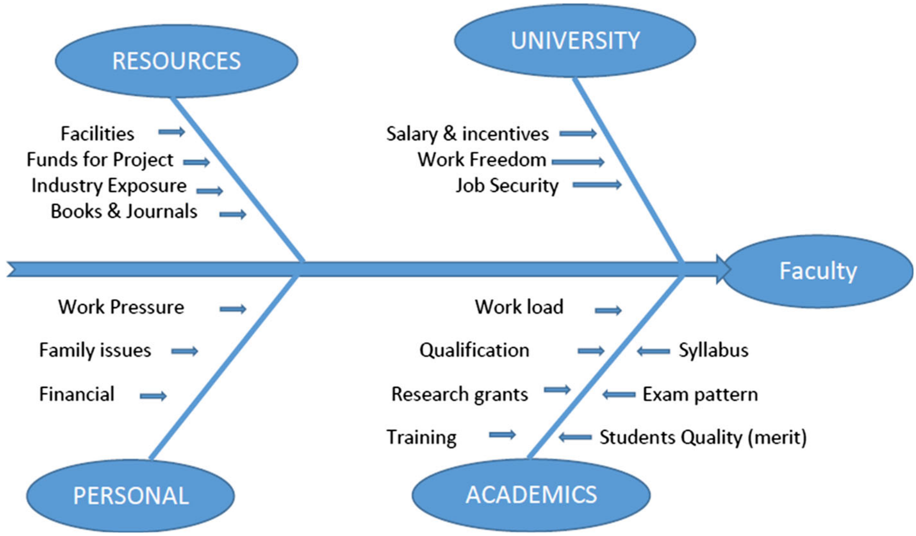

Fig. 3 Root cause analysis of Faculty problems

5.2 Academics

Academics is the core business of faculty member. S/he should be well qualified for the given position and try to keep on upgrading for betterment. Many faculties are not upgrading themselves with the recent trends and development in technologies, which creates gap between the student requirement and their delivery. They should keep on updating themselves with the new teaching tools available in todays world of digitalization. Traditional mode of teaching and non-awareness of the latest evolutions may land them in trouble. Students merit at entry level is also a challenging task for the individuals. They need to adopt proper teaching–learning methodologies which will take care of both below average and merit students. Proper coverage of the syllabus with practical exposure and skill should be taken care. Frequently changing exam pattern is also a challenge to faculty.

Faculty should attend various quality improvement programs to upgrade themselves. They should also be involved in research activities and should try fetching the grants for various research projects from different funding agencies.

5.3 Resources

If the faculties are not provided with proper resources, it is the major cause of failure and poor delivery. Facilities like high tech library with books, journals and e- resources should be made available. Requirement from industries should be known to faculty. Faculty exchange and participation in industry should be augmented. Non-availability of funds for research may stop further development. Therefore proper funding should be made available by universities or other funding agencies.

The college infrastructure plays a vital role in the teaching–learning process. For proper learning, a college should have basic recourses on the campus like; digital classrooms and laboratories with proper equipments.

5.4 Universities

A university plays a major role in framing the policies. It should involve academicians and industrialists to frame the syllabus, and should give freedom to upgrade it from time to time. Salary norms should be properly fixed and monitored. Incentives should be given for extra work allotted and research carried out by faculty. Freedom to work on research proposals and teaching–learning process should be given to faculty.

After analysis, the problems faced by faculties and students by Fishbone diagrams, it is recommended to implement Outcome based education (OBE) in engineering colleges of India. “OBE can be taken as a theory (or philosophy) of education in the sense that it embodies and expresses a certain set of beliefs and assumptions about learning, teaching and the systemic structures within which these activities take place” [21]. For achieving the expected outcome for the specified programme/course, flexibility of Curriculum design is required. OBE gives freedom to implement the methods as per their choice, which may vary from teacher to teacher. There is no particular style for teaching and assessment. Students are expected to learn themselves with teacher as a mentor, guide or facilitator. The teaching–learning process should help students to achieve the required outcomes. The overall development of students should be achieved by imparting proper knowledge, acquiring required skills and developing the attitude. Students are expected to be able to do more challenging tasks other than memorize and reproduce what is taught. They should be more creative, able to analyze and synthesize information, they should be able to do project, show their abilities to think, question, research, and make decisions based on the findings. Graduates should be industry ready and all-rounder [22].

OBE is been successfully implemented in many countries, the case studies are available for references. Dr. Jake et al. [23] implemented OBE in Lyceum of the Philippines University—Batangas to identify the extent of knowledge and practice of the Engineering Faculty Members on the OBE.

Critical review of the outcomes-based approach to quality assessment and curriculum improvement in higher education in China was made by Maureen Jam. According to survey the teacher-centered model is shifted to student-centered model [24].

Case study for Faculty of Commerce and Management Studies was done for Outcome-based education (OBE) using Student-centered Learning (SCL) at University of Kelaniya, Sri Lanka [25]. Similarly, P. H. Kusumawathie et al. in their survey on application of outcome based curriculum design strategy for secondary school, also suggests as a result of their research, that outcome based education is superior to the traditional teacher centered objective based education [26].

6 Results and Discussion

By using Fishbone diagram, it is easy to reach the root cause of the problem. Four major aspects of the source of problems are identified with students and staff. Attempt has been made to find the root causes of the same. Similarly other stakeholders and teaching–learning process can be evaluated and solution to be worked out.

Considering the problems faced by students and staff, following points are suggested:

1. Before starting professional courses students should go through foundation course to merge the gap between +2 level and immediate curriculum to be studied.

2. OBE system should be practiced. Assessment of the students should be on continuous basis.
3. Project based learning, Activity Based learning and Case based learning should be promoted.
4. Students should be made aware of cutting edge technologies. If not possible in structure, minor subjects can be offered.
5. More emphasis should be given on practicals and hands-on training. Skills should be developed to make students industry ready.
6. Stipends and research fellowship should be awarded to students by universities for their Ph.D. programs.
7. University should offer need-based and job-oriented courses.
8. Personality development programs should be promoted along with curriculum.
9. Hi-Tech library facility should be made available.
10. Examination pattern should be properly reformed.
11. University/institutes should sign MOU's with Industries.
12. Faculty development programs should be organized by institutes.
13. Faculty exchange and participation in industry should be increased.
14. Institutes should utilize the human resources available in Industries as expert lectures and arrange industrial visits for students, provide internships and industrial projects.
15. Involvement of research in institutions and industries should be promoted.
16. Industries should utilize infrastructure and human resources available in universities for problem solving, testing and certification.
17. Institutes should promote entrepreneurship in education system.
18. Institute–Industry interaction should be enhanced.

The problems identified as a case study in Sandip Foundation, Engineering institutes are analyzed. The solutions proposed are now been implemented in Sandip University, Nashik. To overcome the above problems, Outcome based Education, as suggested, is implemented and the results obtained are found to be improving as compared to other institutes with non-OBE pattern. Students feedback has also improved by implementing few of the above suggested solutions.

Similarly, the analysis of other stakeholders can be done and transformation could be made taking into consideration the root causes of problems identified in this study.

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Triangular model: Ultimate regime to enhance efficacy in the Technical education.

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Abstract: The technical education in India is on radar due to the poor employability of the graduates. The enrollment of students in technical education is drastically reducing year by year. To focus on this problem a survey is conducted, in engineering institutes in India. The purpose is to examine the lacunas in the technical education system. Based on the analysis, the triangular model is suggested, which is an ultimate model to increase productivity in the Indian education system. Herein, we have performed the survey based analysis for ~1800 students from three technical institutes from two different Universities in Maharashtra. In this model, we have chosen three vertexes with free to consign anywhere during trials on students. The vertex is student, faculty and lastly effective academic environment. Although, to increase the overall efficiency of student and teacher, we have initiated the triangular model using power law. However, the power-law has a generalized innovative capsule to increase the effective coefficient rating, which automatically increases the number of technical skills towards students.
Keywords: Triangular models, Power law, Sandip University, Higher technical education.

1. Introduction

Technical education plays a vital role and acts as the backbone for the development of the country. The quality of human beings might enhance the development in industrial efficacy and improve the lives of people. The first engineering college was developed in UP, in India, during the year 1847 with a Civil Engineering branch, thereafter from the year 1880 onwards Electrical, Mechanical and other branches progressively commenced in different institutes. In spite of developments, in technical education, the current scenario of employability and skills is not satisfactory, it shows the need to analyze and to rethink about the Indian technical education (Report 2017).

Considering the problem of employability, “Make in India” project was launched by Indian Prime Minister to boost up start up projects by budding entrepreneurs (Make in India 2014). Various skills based trainings, seed funding and facilities are given to start new projects. Young mind has potential creative ideas which can be used to increase the research also, which will help in increasing the job opportunities. But, it seems to be lacking behind with some of the parameters discussed later in this paper. Also, during the golden era of more competitiveness, the quality, in terms of technical and skill set, required in graduates qualifying from engineering colleges seems to be below level. The dearth lies in quality, not quantity. According to recent survey regarding employability by the Aspiring minds firm, only 19.11% of graduating engineering are employable (Minds 2019) (Shinde Dnyandeo, Srivastava, and Prasad 2018).

There are plenty of opportunities for improvements to be done in technical education for enhancing quality of students for better employability. The initiative is taken to analyze the facts, and propose a model to find the root cause of poor employability in the Technical stream from Indian Universities.

2. Review of Literature

The enrollment ratio in Technical Education is gradually decreasing every year, as per the All India Council of Technical Education (AICTE) report (AICTE 2019). The stats show that as compared to 2015-16 there is a reduction of more than one lakh thirty thousand students as compared to intake for A.Y. 2016 – 17 followed by drop by more than fifty thousand student enrollment in next A.Y. (AICTE 2019).

to identify the factors affecting the Effectiveness in Technical Education (Sahu, Shrivastava, and Shrivastava 2008). Accordingly, they suggested major factors governing effectiveness as: Teaching Effectiveness, Infrastructure, Research and Development, and Extracurricular Activities. Thus, recommended the mathematical model in order to enumerate it. Technical education system since independence is described by Damayanti Sen, also she shared majors taken by government to improve it. (Sen 2016).

Many educationalists have adopted Total Quality Management (TQM) as the basic tool to enhance

Table 1. : Engineering – Course v's Intake/Enrollment and placement for the AY 2016-17 (Source: AICTE) (AICTE 2019)

Sr No.	Discipline	Intake	Enrollment	% enrollment	Placement	% Placement
1	Mechanical Engineering	802484	422992	52.71	144363	34.1
2	Computer Science Engineering	587244	320081	54.51	112712	35.2
3	Electronics and Communication Engineering	556236	233825	42.04	100383	42.9
4	Electrical Engineering	442296	215083	48.63	69120	32.1
5	Civil Engineering	507664	261589	51.53	54104	20.7
6	Chemical Engineering	36190	20883	57.7	6275	30
7	Textile Engineering	12445	6358	51.09	2201	34.6
	Total:	2944559	1480811	Avg.: 51.17	489158	Avg.: 32.8

Table 1, shows the enrollment of students in engineering branches. Enrollment is just 51.17% of the intake, & as compared to enrollment, only 32.8% placement is seen. It means nearly 67.2% of engineering students are without employment. As compared to the ratio of increase in new institutes and lateral entry in the intake, the placement options available are very less. (AICTE 2019).

There is need to brainstorm and act in the direction to increase enrollment ratio of the students by making them employable. For the analysis of the stakeholders – Students, Staff and Employers are to be made. An attempt has been made, to find out the root cause of problems faced by the staff and students in technical institutes, by Shinde et al. (Shinde Dnyandeo Dattatraya, Ahirrao, and Prasad 2018). Sahu et al. attempted

the efficiency, effectiveness and excellence in technical education. (Thareja 2017) (Syed and Mohammad Naushad 2014).

Corrective steps are taken by the Government of India, AICTE, and MHRD by revising the policies for improving the quality of the technical education. Also, it is made mandatory to follow the basic norms for infrastructure, quality of teachers and research, etc., through making it compulsory for the institutes to accredit themselves through various bodies like: National Board of Accreditation (NBA) and the National Assessment and Accreditation Council (NAAC). However, the ground reality regarding following the norms laid down by governing bodies by the institutes is to be reviewed from students and parents. An initiative is taken to enhance the productivity in higher (technical) education so as to ensure that engineering graduates possess the basic skill and quality to be employable. The survey is being done to investigate the problems from the point of view of students.

3. Methodology/Experimental Set Up

The survey-based analysis is made in this study. The data were collected through a survey of students from the technical institute in Maharashtra, India, in March 2018. The students are from engineering program. The program is of four years duration, the data are collected from second year to final year students in hard copy on paper. The open ended questioner was floated consisting only one question. Students were free to write their opinion. The institute chosen for analysis was:

1. Sandip Institute of Technology and Research Centre (SITRC), affiliated to University of Pune.
2. Sandip Institute of Engineering and Management (SIEM), affiliated to University of Pune.
3. School of Engineering and Technology (SOET), affiliated to Sandip University, Nashik.

From above institutes, the number of responses received from students is shown in Table 2.

Table 2. : Number of Responses from different institutes

Sr. No	Institute	No. of Students for Feedback
1	SITRC	989
2	SIEM	836
3	SUN	408
Total Responses:		**2233**

Total 2233 students contributed their feedback, out of which the analysis shown is for 1800 students. Analysis of the data is presented in the form of the power law.

Analysis of the Sample:

The survey was scheduled for sample size of 2500 students, accordingly invitation was floated. Out of which the response of 2233 students was obtained. Thus giving the response rate of 89.32%. Few feedback sheets received were blank, few were incompletely solved, and thus rejected. Total completed sheets for analysis were 1800. The completion rate is 80.61%. The analysis shown is for 1800 students based on the survey sheets. Respondent answered questionnaire with only one open-ended question. One of the response is attached in Appendix – A.

Characteristics of the respondents:

The respondents are from Sandip Foundation's, Engineering Institutes, Nashik. The data collected is characterized as per their semester/year of the course, branch etc.

Analysis of Data:

The data is analyzed by the author using statistical software. Many parameters are analyzed in statistical Origin 8.0 software. The students' feedback is analyzed and classified into thirteen characteristics which are to be focused to enhance quality of the technical education:

1. Academic
2. Psychological
3. Finance – Fees/scholarships
4. Caste
5. Human values/ Employability.
6. Innovation/R&D
7. Industrial Visit/ Workshop & Seminar / Value Added Programs.
8. Professional Languages/ Communication Skills
9. Sports
10. Time Management
11. Technical
12. Infrastructure
13. Business/ Entrepreneur

Out of above parameters, second point i.e. psychological issues are being addressed in authors, one of the papers presented in Global Wireless Summit 2018, Thailand. The paper addressed the solution by implementation of Yoga. (Shinde Dnyandeo, Srivastava, and Prasad 2018).

4. Result and Discussion

The study has introduced the new concept to analysis the system of education, according to the students' feedback. Herein, we defined the power law that has directly influenced the rating of the students' problems faced in the technical education. Academics has the major responses noted, so a focus is on academics. A generalized formula based on power law is introduced to solve these Academics and its essential parameters which directly influence the students. The survey of more than two thousand students has forced to unravel this problem for technical education.

The output of the survey was tabulated considering the thirteen points on which students focused on their feedback. The power law is proposed to consider a key element as Academics, which has the highest responses of 642. Table 2, shows the log values of Academics (μ) concerning students (A) / faculties (B), deviation point (K) for all the 13 parameters.

Power Law: $\mu = K\,A^{B}$………. (i)

Herein, power law has been transferred to straight lines, so that it is easy to calculate different parameters.

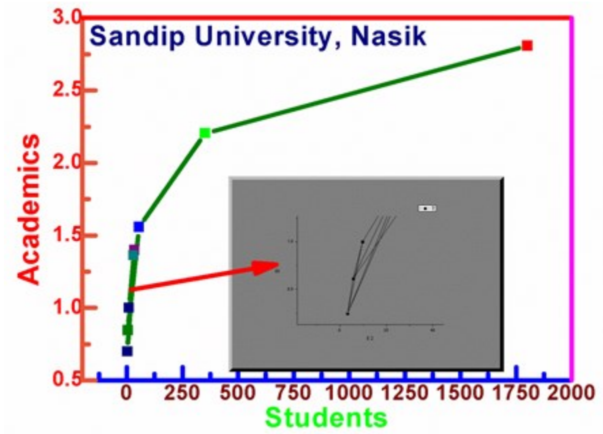

Fig. 1: Non-linear curve indicates three vertices which obey a power law

In the present study, we have proposed the model for the three cases – Academics, Students, and Faculty, to enhance the productivity of the three vertexes in the triangular model. During the triangular model, academics come on the first property which sustains the educational Institute. As we move further, due rotation of the axis, it causes students to come at the topmost position in the vertex of the triangle as shown in Fig. 2.

Table 2.: Power law for technical education system

Sr. No.	Parameters	No. Of responses	**Log (μ) = log (K) +B*log (A)**			
1	Academics	642	2.808	1802.437	-0.301	1802.136
2	Industrial visits/Seminars/WS/ Events	160	2.204	352.659	-0.301	352.358
3	Innovation/ R & D	36	1.556	56.027	-0.301	55.726
4	Professional Languages	7	0.845	5.916	-0.301	5.615
5	Counselling / Psychological	10	1.000	10.000	-0.301	9.699
6	Technical	5	0.699	3.495	-0.301	3.194
7	Sports	7	0.845	5.916	-0.301	5.615
8	Infrastructure	10	1.000	10.000	-0.301	9.699
9	Time Management	25	1.398	34.949	-0.301	34.647
10	Industry / Site Sector	5	0.699	3.495	-0.301	3.194
11	Caste	7	0.845	5.916	-0.301	5.615
12	Finance	23	1.362	31.320	-0.301	31.019
13	Business / Entrepreneur	5	0.699	3.495	-0.301	3.194

At this we consider, to propagate further to improve the system in technical education, our group has proposed a power law to solve this complex problem.

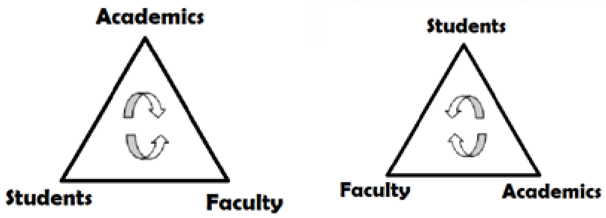

Fig. 2: Triangular model in terms of education system

Based on the model, we have a plot of the logarithmic curve in terms of straight lines, which is used to predict the academic requirements in the students, with the help of software Origin 8.0. In the initial terms, to 500 students, academic requirements follow a directly proportional power law. As we move on the further study, academic requirement between three vertices increases up to 2.7, it believes that the academic curriculum is very much useful to the students of the current batch of the Sandip University, Nasik. Herein, our group has used a triangular model, which is rotated to itself with three degrees of freedom in today's era of the education system i.e. Faculty, Students, or Academics.

Outcome base education was introduced in SOET, Sandip University, for improvement of Academic performance. On this basis, we have introduced effective efficiency (η) of the students using power law:-

$$\eta = (x_1 + x_2 + x_3) * 100/1800 \ldots\ldots\ldots\ldots\ldots\ldots \text{ (ii)}$$

Where,
x_1 = coordinate of one vertex in triangular model,
x_2 = coordinate of the second vertex in triangular model, &
x_3 = coordinate of the third vertex in triangular model

$$\boldsymbol{\eta = 36\text{-}45\ \%} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{ (iii)}$$

It indicates that the outcome based educations effective efficiency has increased from 36.8 % in the Analyst Education system.

5. Conclusions

Based on the rotational degree of the triangular model, we have proposed the power-law, which might be useful in deciding three key factors in the education system – Academic, Student & Faculty. However, in the graph, some values are coming in a zig-zag pattern, which indicates a lack of coordinate with the three degrees of freedoms during the analysis of Sandip University students. Also, it does follow a logarithmic curve, which is indicated in terms of the non-linear coordinate system, to merge the gap of 1800 students with poor and good in the University patterns, and marks are given accordingly with the concepts of the outcome-based education system. Once the Academic is improved, it will result in better employability of the students.

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Appendix – A.

SANDIP UNIVERSITY

Trimbak Road, Mahiravani, Nashik - 422213, Maharashtra.

Opinion Regarding Technical Education
SITRC (TE) Computer

- Must focus on practical ~~stu~~ knowledge, as compared to written test.
- Practical exams should be conducted as much as possible.
- The industrial visits must be conducted for technical knowledge of student.
- Less focus of theory exams.
- Attendance criteria should be ~~less~~ changed.
- Faculty must try to give practical knowledge to students.
- Viva should be conducted.
- Write-up or assignment should beless

42

SANDIP UNIVERSITY

Trimbak Road, Mahiravani, Nashik - 422213, Maharashtra.

Opinion Regarding Technical Education
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42

SANDIP UNIVERSITY

Trimbak Road, Mahiravani, Nashik - 422213, Maharashtra.

What is your opinion regarding indian Technical education?

→ 1) I expect that education system should focus more on practical learning than theorotical learning.

2) Marking system should be based on the practical performance of the student and not based on their theorotical answers/written exams

22

SE
SIEM
BE Computer

Mobile Learning: Steps towards Transforming Traditional Learning to e-learning

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***Abstract*— In today's world of digitization, each field is rapidly using modern technology for achieving fast and better results. Traditional methods of booking tickets at station/shops, purchasing the articles in malls, and others are replaced by online booking and online purchasing, reducing the efforts and is faster. Even the comparison of the products is possible at the fingertips instead of window shopping. The rapid growth of digitization also marked in the field of education. The younger generation is more techno-savvy, and the use of smartphones and the internet is rapidly increasing. The area of education is also transforming with the use of ICT. Internet tools find their application for learning. It's time to change the traditional method of teaching from chalk and talk to e-learning. The paper shows how effective the use of mobile can enhance the teaching-learning process. The article highlights the use of wireless technologies in the Education sector.**

Keywords*— *Mobile Learning, e-learning, ICT in education

I. Introduction

The use of digital technology is increasing globally. Traditional methods of trading, business, communication, teaching, and others are rapidly being takeover by wireless technology and its application. The paper focuses on the education sector. Information Communication Technology (ICT) is a process of information exchange, using a common platform. Applications of ICT seen in various fields, Vishwakarma described the use of mobile and wireless technology in a Library with Indian context [1]. The use of mobile in learning has transformed e-learning to m-learning. The Framework for the Rational Analysis of Mobile Education (FRAME), was well defined by Ally [2]. The FRAME model describes a mode of learning in which learners may move within different physical and virtual locations and thereby participate and interacts with other people, information, or systems – anywhere, anytime [2]. Ally also discussed various challenges and opportunities, the use of mobile technology in multiple fields like multimedia tourism, teacher training, nursing practice, informal learning, etc. Now, the transformation of E-learning is to m-learning is being observed.

The few differences between E-learning and m-learning: – E-learning is using internet lab setups or lectures in the classroom, e-mail to e-mail at some private location. One has to move to a particular area of the internet site, travel time, and availability are considerable. In contrast, m-learning is anytime, anywhere, instant messaging with no geographical boundaries, no travel time with wireless internet connectivity to handy devices like palmtop, smartphones, etc. [3].

II. Literature Review

The use of mobile for learning has been increasing. According to Paliwal, mobile learning can be a future trend in education if colleges and universities accept mobile learning as their usual means of communication. IBM has recommended building an Education Collaboration Network (ECN), which should achieve New models for designing curricula, creating training material and teaching aids, and providing access to it [4].

China and India have the maximum contribution in mobile users in Asia- Pacific, with 880 million and 470 million users, respectively (in 2012). In India, Pakistan, and Nepal, gender disparity is an additional roadblock along with infrastructure, lack of educational policies [5].

UNESCO has taken the initiative to spread of mobile learning, through the series of working papers. The series gives a better understanding of the use of mobile technologies to improve educational access. The series provides information regarding how mobile learning initiatives and their policy implications, and how mobile technologies can support teachers and improve their practice [6]. The educational policy proposed for Asia has four broad categories: Basic education, Knowledge acquisition, knowledge deepening, and Knowledge creation [7].

Qualcomm, through its Wireless Research, is also funding various projects. Out of 100 projects in 40 countries, 40 projects are focusing on education. The report focuses on eight essentials for a successful mobile learning initiative in primary and secondary schools [8].

A UNESCO initiative on the working paper series on mobile learning has revived and recommended mobile use for education. The review describes the various projects used to support teaching-learning in Asia, viz. Text2Teach, University of Philippines Open University (Philippines), SMS for language learning (Hong Kong), Literacy Promotion through Mobile Phones (Pakistan), Boat School & Incentives to improve health knowledge through Mobile Phones, BBC Janala (Bangladesh). Many teachers' development programs successfully implemented in Asia. Notable projects are Intel Teach and Microsoft Partners in Learning. The challenges faced are the size of the SMS to be sent, reluctant of learners to bear the cost of mobile learning, theft of mobile phones [9].

According to the UNESCO paper series, mobile learning is drastically increasing. Teachers and students are using smartphones in the classroom. Lower price rates on a mobile phone are one of the significant factors for rapidly increased use. It is readily available compared to computer labs and laptops. The use of mobile phones has empowered women and connected to their community outside the home. A mobile phone can support instruction, administration, and professional development. However, reports suggest that educational content, software platforms, and pedagogical models need improvement [10].

M-learning using mobile devices is improving day by day. Kondratova, Goldfarb [11] has elaborated on the use of speech recognition technology, which is useful during field visits of the students. It also gives freedom to the students to enter data hands-free and eye free while focusing on the field visit. The journey of e-learning to m-learning discussed herewith the present pedagogical, technical, and development challenges. Involvement of all the stakeholders in process viz, developers, educators, and students play an essential role [12]. The flexible method of m-learning for these stakeholders with the challenges further analyzed by conducting pre and post-tests to reflect its results in various universities by Kalhoro et al. [13]. The use of m-learning is not only limited to a technical field but is also applied in physical education [14]. The use of m-learning is done with additional features in PowerPoint for effective teaching in Ghana. The STUMP (Skill, Time, User-friendliness, Motivation, and Pedagogy) model is used [15].

M-learning finds its practical use in technical education. For engineering education in Saudi Arabia, the android based application is developed [16]. Zaldivar et al. have investigated the use of mobile learning in computer science [17].
Biswajit has discussed Mobile Learning in India – its Strengths, Analysis, policies & recommendations for the use of the same in India [18]. Kaur has given a brief survey regarding M Learning in India [19]

III. ICT in India

The Indian Government has undertaken various steps for increasing enrollment in higher education and improvement of the quality of education. Multiple activities, schemes are being driven for this purpose.

Ministry of Human Resource Development's mission document reflects the importance of Information and Communication Technology (ICT) to enhance the current enrollment rate in Higher Education. ICT is the tool available. Web portal named "SAKSHAT," is launched by the Indian ministry, and also launched a 'One-Stop Education Portal.' The Education through ICT- National Mission has, under its aegis, created Virtual Labs, Open Source and Access Tools, Virtual Conference Tools, Talk to Teacher programs.

The Various Programs undertaken by the Government of India under ICT are listed below:

NPTEL – National Program on Technology Enhanced Learning. Video-based / web-based teaching-learning material of high quality is made available for engineering education, by Indian Institutes of Technology (IIT) and Technical Teacher Training Institutes (TTTI).

Virtual Labs - Labs in various disciplines of Science and Engineering get remote-access through this. These Virtual Labs would benefit UG, PG, and research scholars.

Talk to Teacher – Live audio-video streaming makes it possible for a large number of learners, from multiple locations, to learn through a single teacher on a real-time basis. An advanced multi-platform, collaborative e-learning solution is provided for this.

Spoken Tutorial – It is an online discussion forum.

CEC - The Consortium for Educational Communication (CEC), set up by the University Grants Commission of India. It addresses the needs of Higher education through Television with the use of ICT.

E-Yantra – To help to shape next-generation embedded systems engineers, undertaken by IIT, Bombay.

Digital Library Inflibnet - Information and Library Network (INFLIBNET) Centre. Aims in modernization and digitization of libraries.

Quantum and Nano Computing - Dissemination of knowledge in Quantum-Nano Computing to Industries / Research and Development Organizations and academia.

ERP - The ERP mission is to Implement, maintain, improve, and support the County's integrated financial, procurement, human resource, and payroll information systems.

Indian Sign Language Education and Recognition System.

MHRD - Ministry of Human Resource Development (MHRD) established for the development of human resources. The Digital Saksharta Abhiyan (DISHA) or National Digital Literacy Mission (NDLM) Scheme formulated to impart IT training.

Digital India program launched by the Government of India promotes the use of information technology to transform the entire ecosystem of public services. A vision of the program is "transforming India into a digitally empowered society and knowledge economy" [20].

The Digital India program - the flagship program of the Indian Government, has a vision to transmute India into a digitally enabled society with the knowledge economy. It is an umbrella program that covers numerous government ministries and departments. The Government will implement it with coordination done by the Department of Electronics and Information Technology (DeitY). Digital India aims to boost nine pillars of growth areas, viz. Universal access to Public internet access program, mobile Connectivity, Broadband highways, e-Kranti, Electronic Delivery of services, e-Governance, Information for all, IT for Jobs and early harvest programs, Electronics manufacturing.

The project – Mobile and Immersive Learning for Literacy in Emerging Economies (MILLEE) in India investigates how mobile phones find its application to enhance English Language skills, a research-based initiative [21]. The Mobile Vocational Educational Programme (MOVE) for rural India operates through the Sakshat Amrita Vocational Education (SAVE) project [22].

SWAYAM: SWAYAM or Study Webs of Active –Learning for Young Aspiring Minds is a program initiated by the Government of India has designed to achieve the three cardinal principles of education policy viz., equity, access, and quality. Keeping the objective to take the best teaching-learning resources to all. SWAYAM courses hosted has four quadrants – (1) Audio-video lecture
(2) Reading material with downloaded or printed options.
(3) self-assessment tests through quizzes and experiment, and
(4) an doubts solving online discussion forum.
Massive Open Online Courses (MOOCs) have the tremendous potential to make higher education accessible to India's youth.

IV. M-LEARNING AS A TOOL IN TECHNICAL EDUCATION

In India, various projects operate under ICT and Digital India. However, the learning observed is more informal than formal learning. Mobile users are increasing day by day. Students from schools and colleges are using mobile, but the applications are games and social media. The use of mobile for formal learning is missing. The use of social media like WhatsApp and Facebook is increasing in students. Social messages are being circulated instead of actual knowledge.

As seen in the literature, the size of SMS is one of the challenges in sending study material. For this above mentioned, social media sites and software are readily available. Groups of the students, teachers can be formed for chatting. It is the fastest and readily available mode of communication.

For professional learning, animations can be created based on the concept and working principals and circulated amongst the students. Discussion and doubt solving regarding the animated clip recommended, which will solve the purpose of the assignments. Increase student's involvement in developing the apps and animation with better use of the audiovisual effects for enhancement of the teaching-learning process through organizing various competitions. It will increase their interest in education.

Training to teachers' and awareness regarding mobile use planned for productive use. It will enable them for effective use of the mobile phone for attendance, circulation of notes, assignments, tutorials, and discussions.

V. ICT IN SANDIP UNIVERSITY

Regarding the various applications available in India for ICT. Sandip University has taken the initiative to implement the same in the curriculum. The use of the NPTEL program implemented successfully. All the lectures are available to the students in e-library on university servers. Students select minor subjects based on their choice through online course options. The certificate issued online counted in their credits of the course. Teachers are also uploading the notes, assignments, and presentations online through the Google classroom. Online lectures recommended through Zoom or similar software.

e-learning in COVID – 19 pandemic: The COVID-19 pandemic has affected the entire world. The lockdown is observed in many countries since January 2020. In India first lockdown was declared in March 2020, which affected every sector including education. Personnel and in campus teaching in institutes and universities is not possible. In beginning, everything was close excluding emergency services, everyone waited for the situation to improve. But, unfortunately, the situation was getting worse and worse day by day due to increase in infection rate of covid patients, and there was no chance for schools/colleges to open. Slowly, online seminars, webinars, and discussions started. Then the teaching-learning process also started online. Software's like Zoom, Google-meet were used for online teaching.

In Sandip University the teaching continued with online mode. Initially, faculties used Zoom, Google-meet, Jio-meet, and other similar software to connect with students and conduct online lectures. Study material including notes, assignments, audio/video contents, recorded lectures, etc. was made available to students on Google classroom and similar apps. Assignment and test were also conducted online with various options available. Multiple Choice Questions (MCQ) based test is available in many software including Google classroom. There are few options available (mostly on a paid basis) for summative assessment. The author tested the summative and online base test by using Oxloop software. The available software was modified as per the requirement.

Results of Oxloop online learning platform:
For online teaching learning process many options are available and faculties are using it as per their requirement and convenience. As an example the details of the Oxloop software used are discussed as a case for effective teaching learning.

The class wise/ course wise folders are created for enrolling the students and share the required contents for the particular course with the students. Fig. 1 shows the course wise folders and various other options available in the software. Student has to download the software and send request for enrollment, faculty confirms the enrollment of the student in particular course. Then each student has to login with his credentials to access the data of the course. All the study material is uploaded and visible to the students.

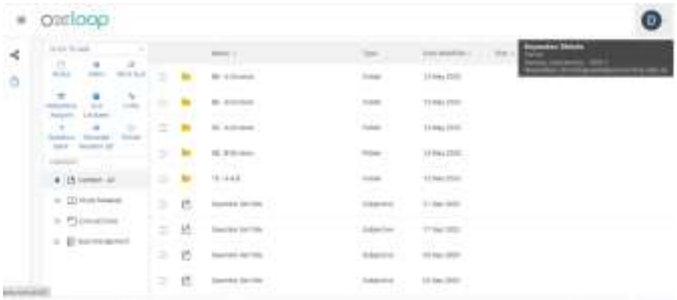

Fig. 1 Oxloop – menu bar and Course wise folders created

Assignments/ exams – MCQ based as well as summative can be scheduled for the students individually or for group. Fig. 2 shows the assignments scheduled and details regarding their submission status.

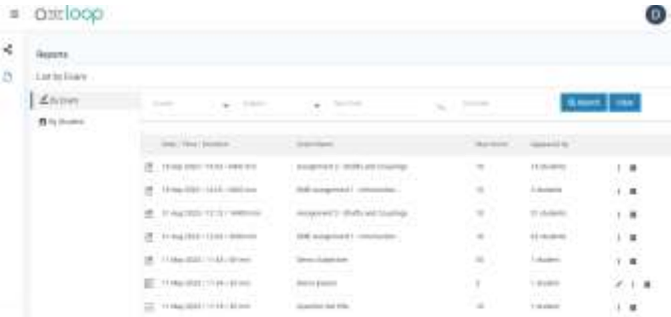

Fig. 2 Oxloop – Exam view Scheduling of Assignment and tests

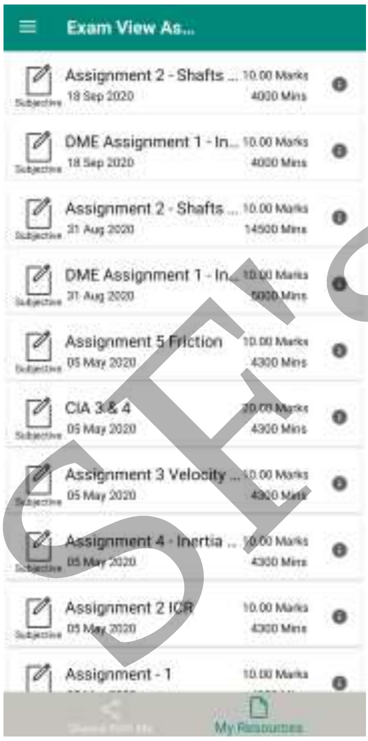

Fig. 3 Assignment and exam view

Summative assignments/exams are scheduled for the students. Fig. 3 shows the checked assignment (first and last page) with remarks and marks.

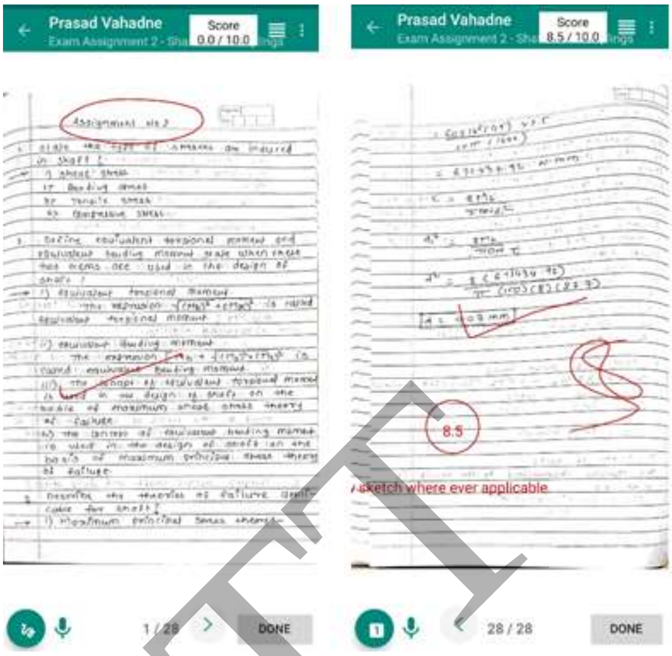

Fig. 3 Summative assessment check.

Student attempt the same by downloading it, solve it in give time and they upload the solved assignment/paper by taking photographs of it, which is uploaded in pdf format. Teacher can access the same online by touchscreen on his tablet or mobile phone.

Fig. 4 shows the details of the assessments assessed by the faculties. Instructions can be given to the students in form of remark or voice recording, which can be seen/referred by the student once the teacher has uploaded it.

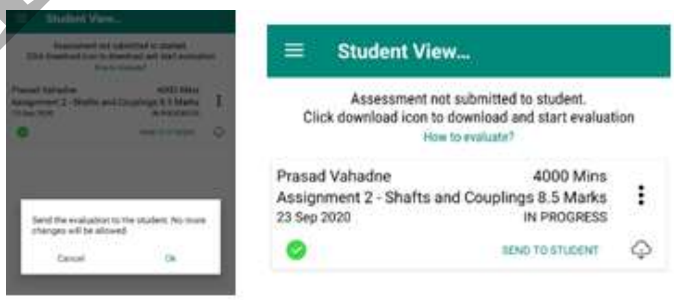

Fig.4 Download and upload assessed sheets

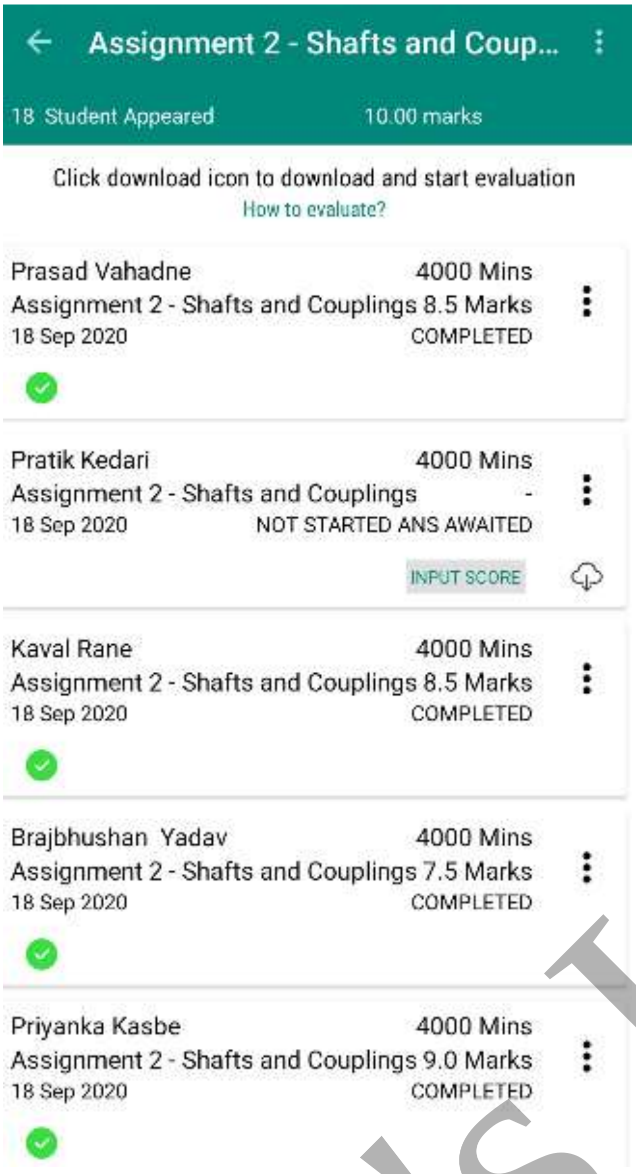

Fig. 5 Student view of assessed sheets

There are many other options and facilities available in the software. MCQ based test can be taken, video links can be shared, lecture links can be scheduled, etc. The use of effective e learning tool has made teaching and learning easy.

CONCLUSION

The use of ICT for the education sector is discussed in this paper. The transformation of E-learning to m-learning was observed due to rapidly increasing technology in electronics and smarter mobiles available at a lower cost. COVID – 19 pandemic has made it compulsory to use this technique for teaching. Due to increased requirement of online learning e-learning is rapidly capturing the market. It helps to broaden the scope from poor to rich. In India, specific challenges recommended to addressed by taking advantage of the Digital India project. M-learning can be effectively used in technical education by developing various applications, animations, and techniques. Author has shared the experience of Oxloop e-learning tool effectively used for teaching learning.

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Digital Transformation in Technical Education

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***Abstract*— Technical education is improving day by day. The student employment ratio is reduced, due to the gap, between the knowledge imparted and the requirements of the industry. An attempt is made to analyze the causes of poor employability and results through a case study in Indian universities. And the business model is proposed for the betterment of the quality of technical education to enhance productivity, employability of the students. As per the analysis, a significant factor affecting the quality of education is academics. Few changes are suggested, in enhancing the quality of technical education, like Industry Institute bounding and digitalization of the teaching-learning process, etc. Suggestions can be implemented as a business model, in the technical institutes, for the betterment of quality education.**

Keywords—Technical Education, Business Model, Digital Technology

I. Introduction

The quality of technical education is at stake due to poor employability. As per the statistics published by All India Council for Technical Education (AICTE), the enrolment ratio and placement are decreasing in engineering and technology stream [1]. Fig. 1. shows the graph of the intake, enrolment, the student passed and the placements till the academic year 2018-19. The number of technical institutes is increasing, and the enrolment is decreasing, which has affected in maintaining the proper infrastructure and faculty quality required in the technical institute. The review of technical education is presented by Shinde [2], and suggested, necessary steps to investigate the Indian technical education system.

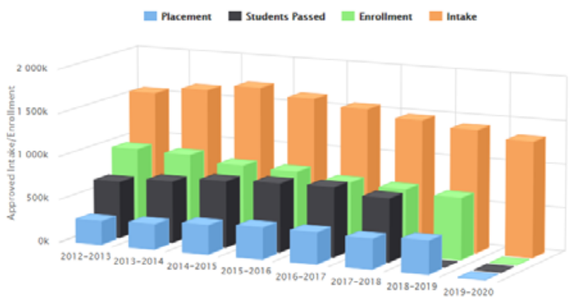

Fig. 1. AICTE: Institutes, Placements for Engineering and Technology 2018-2019, UG (Source: AICT website)

The study is based on the survey conducted in different technical institutes belonging to Indian universities. The major parameters for unemployment and poor quality of education are identified, and examined from the survey report, the necessary solutions are recommended.

Sponsored by: Sandip University, Nashik, India

II. Review of Literature

Technical Education plays a major role, in developing the country's economy. Technology has a great impact on society in day to day life [2]. Technical education should be supported, with required skill sets. Innovation and incubation centers are to be developed to enhance skills in the students [3]. A lot of research is being done for the betterment of technical Education in all respects. Technical education has seen lots of changes in the last few decades. Outcome-Based Education(OBE) is also being implemented and various case studies are available [4]. Education is marching towards digitization. As per the analysis of IEEE EDUCON 2014-2016 conference papers, the digitalization in engineering education is increasing [5][6]. Impact of digitization is reflected from the topic of research to teaching methodology [6]. Smart education is upcoming to compile education with industry 4.0 [7]. "Digitalization means the transformation of all information types (texts, audio-videos, visual presentations, and other data from various sources) into the digital language". Future classrooms will be dealing with the minds of the students in terms of innovation and creativity, with the out of the box thinking. Students will not only memorize and reproduce theory in test papers but will be able to apply it logically [8]. A modern classroom is an Information and Communication Technology-based (ICT) classroom. Traditional classrooms are converted into interactive sessions by combining the best hardware with syllabus-compliant, multimedia content [9]. A virtual learning experience is effectively used in the digital transformation of engineering education [10]. The digital teaching learning gives better results but also has some challenges [11]. Blended learning is also an effective teaching-learning tool in the modern era. [12] Engineers are to be imparted with business managerial skills, as techno managers are needed for future industries [13]. Few challenges in higher education are also discussed by Dawar et. al. [5] concerning different stakeholders – teachers, students, industry, parents, etc. The role of women in developing higher education is also very significant [6]. Students are considered as consumers of higher education [7]. The role of all the stakeholders related to higher education is to be considered and studied at the minor level. The root cause of problems related to staff and students is analyzed by Shinde et. al. [8]. Further, the solution to the problem related to stress is suggested as Yog Nidra in authors, one of the papers [9].

III. Methodology

The survey is conducted in various institutes from different Indian Universities in Maharashtra state. The data presented is from three institutes: two Institutes – Sandip Institute of Engineering and Management (SIEM) and Sandip Institute of Technology and Research Center (SITRC), affiliated to University of Pune and one institute, School of Engineering

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and Technology (SOET), affiliated to Sandip University, Nashik. The data are collected through a survey for students from second year for final year to four years engineering program. The questioner type is open-ended. The analysis of the data of 989 students belonging to above mention technical institutes is taken as a case for discussion in this study. The data are sorted for further processing.

Analysis of the sample: The survey is planned for 1200 students, out of which the response is obtained from 989 students. Each respondent has to answer only one open-ended questionnaire.

Characteristics of the respondents: The respondents in this study are from three different institutes. They are characterized in terms of their semester/year of the course and branch.

Analysis of data: The main purpose of the initiative is to identify the root cause of failure of students and less employability of engineering students [1]. From the analysis nine major parameters are identified and discussed.

IV. Result and Discussion

The student's feedback is analysed, the study has identified nine parameters to be focused for improvement of technical education. The frequency of responses is marked after the analysis in Table 1. The findings clearly indicates that the academics plays important role in response to the students feedback. The second major findings is regarding industrial visits and workshops to be conducted.

Table 1. Parameters and frequency of responces from students

Sr No	Parameters	Freq.
1	Academics	843
2	Industrial visits/ Seminars/ Workshops / Events/ Value added programs / Co Circular activities	284
3	Innovation/ R & D /New Technology/ Technical/ Industry/ Abroad	82
4	Professional Languages / Soft Skills	97
5	Counselling / Psychological/ Human: Mind and Body / Stress/ sports	41
6	Infrastructure / Books/ Labs/ Wi-Fi/ smart Class room/ Library	19
7	Time Management / Attendance / Exam Timetable	41
8	Caste/Cost/ Fees/ Finance / Scholarship	77
9	Business / Entrepreneur/ Employability	39

1. *Academics:*
   Maximum students are discussing on the academic issues. The highest frequency of comments is received related to academics, so it is analysed and discussed further in details as tabulated in table 2.
2. *Industrial Visits/ Seminars/ Workshops/ Events/ Value Added Programmes - VAP/ Co Circular activities:*
   This is another major parameter in the student's discussion. They urge for more industrial exposure and practical based workshops, events, value-added programs (VAP) to be conducted to get the experience of an actual industrial environment.
3. *Innovation/ R&D/ New Technology/ Technical/ Industry/ Abroad:*
   Students are also curious to learn new technologies, connect themselves in research and development, and would like to go for higher studies in other countries. Research facilities and supervision should be provided to the students. They should be given industrial projects and solve industrial problems as a part of their research projects with their professors. Research projects should be given to students to bring awareness regarding the industrial requirements and social impact [14].
4. *Professional Languages/ Communication Skills*:
   Students should be given exposure to learning professional languages. Their communication skills should be enhanced.
5. *Counselling/Psychological/ Human: Mind and Body / Stress/ Sports:*
   The passing percentage of engineering graduates as compared to intake is also very less in Indian Universities. Many students are psychologically depressed due to poor grades. The counseling of the students is a must. They should be tuned with stress-relieving techniques such as meditation, Yoga, sports activity, etc. to refresh their mind and body. Fig. 2 shows the implementation of Yoga as a stress-relieving tool for students. Similarly, they are trained for physical fitness as shown in Fig. 3.

Fig. 2. Students performing Yoga at Sandip University, Nashik, India

Fig. 3. Training of Physical Exercise to the students of Sandip University

6. *Infrastructure / Books/ Labs/ Wi-Fi/ smart Classroom/ Library:*
   Proper infrastructural facilities should be given to students like laboratories with all possible experimental

setup, smart classrooms, digital platform with audio-video facilities, a library with an adequate number and a variety of books, journals, open sources, etc. Students also demand Wi-Fi to go for online courses and explore more through the latest e-resources available.

7. *Time Management / Attendance / Exam Timetable:*
Students are not able to manage time properly to attend the classes and take practical training. They don't want the constraint of attendance to attend theory classes. The exam time table also plays a major role in the student's performance. E-exams can also be taken in times to come [15]
8. *Caste/ Cost/ Fees/ Finance / Scholarship:*
Few meritorious students due to the poor financial condition are not able to study, they need financial support. Category based scholarships, in India, are not recommended by merit students. The cost of studying should be reduced to get more students enrolled for the course.
9. *Business/ Entrepreneur/ Employability:*
Many students are worried about their employment, while a few are planning to start their business and be an entrepreneur. Maximum students should be motivated and supported to start their own start-up company. The government of India is supporting the start-ups through make in India scheme. There are many such options available. Students should be given training and support for the same. Master students should be given entrepreneurship proposal for start-ups[16]

The major responses observed are related to academics. So it is further analysed in detail. The result indicating frequency of response is shown in Table 2.

Table 2. Academic Parameters and frequency of responses from students

Sr No	Parameters	Freq.
	Academics	843
1	Syllabus	318
2	Theoretical/Practical Knowledge/ Project work/ Skills/ PBL	240
3	Exam/Marking scheme/Pattern/CIA	111
4	Teaching Learning process/ Submission/ Staff/ Digitalisation/ Assignments/ Learning material	174

Based on the parameters the corrective measures are suggested and few are implemented in Sandip University.

1. *Syllabus:*
The major concern is in updating the syllabus. In many Universities the syllabus is updated after a cycle of 3 to 4 years, whereas the technology is changing day by day. The syllabus should be updated as and when required, at least for few branches, like computer engineering, the technology which changes frequently should be adopted in the syllabus immediately. The course structure and scheme should be revised, embedded theory and practical pattern should be adopted for maximum courses. More weightage should be given to practical training.

2. *Theoretical/ Practical Knowledge/ Project work/ Skills/ PBL:*
Students complaint is regarding the theoretical based teaching. They want to have more practical training and exposure. Project work should be industry based. Skill based training is to be imparted. Project based Learning, Activity based learning techniques should be adopted. Students should be prepared for working life, they should be introduced with "Practical Engineering" course integrated into engineering bachelor program [17].

3. *Exam/Marking scheme/Pattern/CIA:*
According to student feedback, more weightage should be given to practical marks as compared to theory exams. Marking scheme of examination should be revised. Exam pattern affects the performance of students. Exam pattern like 80:20 (80% End semester exam, 20% internal assessment), 50:50 (50% End semester Exam, 50% online/in semester exam), 70:30, etc. are in use in India in different universities. It is suggested to have Outcome Based Education (OBE). This pattern has 50% weightage for end semester exam and 50% for continuous internal assessment (CIA). CIA is further divided into four components. This help student to study and being evaluated continuously. More emphasis on practical based learning is given in this scheme. Conduction of supplementary exam is promoted.

4. *Teaching Learning process/ Submission/ Staff/ Digitalization/ Assignments/ Learning material:*
Another parameter which affects quality of technical education is teaching learning process. We need to change from traditional modes of teaching to new technological methods. We should go for the digitalization of the teaching learning process. Smart classrooms and laboratories are to be developed. Staffs should upgrade themselves to a digital platform. Students now a days are more techno savvy, they need to be taught by using new teaching methods and teaching tools. New techniques are adopted in teaching at Sandip University for effective teaching, considering the recent trends. The use of cell phones, laptops are promoted as teaching-learning tools. Teaching resources are shared with students using Google classroom and other such internet tools. Activity-based Learning (ABL), Project-based Learning (PBL), Case-based learning (CBS) are adopted effectively in teaching. Outcome-based education (OBE) is followed.
Students are submitting the assignments by copying without understating the concept, which is not deserving. Simply exhibiting the reproduced content is of no worth. There should be some learning outcomes from the assignments. The method of submission/assignments is changed. PBL, ABL related

assignments are given to the students. Submission/ assignments should be fun in learning, not burden or compulsion.

Qualified and well-trained staff recruitment is necessary. Teacher training programs are to be conducted. Staff should develop a new teaching methodology with modern teaching aids available.

Learning material should be in hard or soft copy, supported by audio-video contents. Day to day and recent examples of the related topic is to be given. Case studies are preferred.

V. CONCLUSION

The enrolment in technical education in Indian universities is reducing. The result of this study indicates that academic plays a major role in any technical institute. The modern syllabus with skill base teaching is the requirement of today's generation. The parameters analyzed by the case study are represented. A few suggestions are made and implemented as a business model. The result obtained is satisfactory. The above case study leads to a focus on the root cause of performance and corrective action required for technical education. Notwithstanding the relatively limited sample, this work offers valuable insights into technical education. Although the study has successfully demonstrated that students are more interested in the latest technological updates, skill-based, practical based learning, it has certain limitations in terms of rapid revision in the syllabus, sudden change in teaching-learning process, etc. Further experimental investigations are needed to estimate the root cause of other parameters like exam system, teaching-learning process, and the results after implementing the changes are to be analyzed.

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An Initiative to Enhance Productivity in Higher Education (Technical) using Yoga which interconnect human mind and body

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***Abstract* - The initiative is to enhance productivity in education system using probability index. This helps to create working environment in which work culture directly related to the indexing of rating. In the present study, attempt is to enlist the root causes that affect the technical education, by the innovated generalize formula. It will be useful for academic as well as their key role to teaching learning process of the students for aforementioned application. This would be the initiative project work done with the help of Sandip University, Nasik. An attempt has been made to solve few of the problems by suggesting the proper bounding of Mind and Body by Yoga and Meditation sessions as regular practice in academics.**

Keywords— Technical Education, Teaching Learning Process, Probability index, YOGA.

I. INTRODUCTION

Any country is driven by its human resources, and the Technical Education is the backbone for its development. It helps to create skilled manpower, enhancing industrial productivity and improving the quality of life of its people. Technical Education started in India in the year 1825 by Industrial school in Guindy, Madras. In 1847 first Engineering College was established in U.P. with Civil Engineering branch, from year 1880 onwards Mechanical, Electrical and other branches were added in different institutes. Considering the long history of Indian Technical Education, we have achieved many milestones and created technocrats who are the pioneers in building and development of the nation. The current scenario is different, it forces us to rethink about the technical education in India.[1].

Prime Minister Narendra Modi launched a project of "Make in India" aiming to increase manufacturing in India and generate 100 million jobs by the year 2022. But it seems to be difficult with the quality of graduates passing out from engineering colleges. The survey by employability assessment firm Aspiring minds says 19.11% engineering graduates are employable.[2].

Also, our honourable prime minister has launched 21st June as the international Yoga Day.[1,2]. It's great success shows that YOGA should be practice regularly. Our Sandip University, we strive hard to arrange the YOGA session daily to enhance students Body and Mind balance.

It is also noticed that the technical education imparted to the students is lagging somewhere, which keeps them unemployable. There is gap between the industry requirement and the skillset available in the engineering graduates. The initiative has been taken to find the root cause. To analyse this the survey is conducted in Technical institutes of Indian Universities.

The student's psychology regarding the current scenario of Indian technical education is to be identified. The current study conducted shows the students reflections regarding the requirements from technical education. Which interns to be analysed and new business model to be proposed.

II. REVIEW OF LITERATURE

The enrolment ratio in Technical Education is decreasing day by day. As per the All India Council of Technical Education (AICTE) report there is reduction of 1,31,540 students in intake for AY 2016-17 as compared to 2017-18 and for current year 2017-18 there is further reduction of 53,481students in the enrolment. The enrolment in Engineering branches as shown in Table I is 51.17% of the intake and the placement is 32.8% of the enrolment. It shows that 67.2% of engineering students are unemployable. The proportion of increase in number of institutes and intake is very high as compared to the placement options.[3]

TABLE I. ENGINEERING – COURSE VS INTAKE/ ENROLMENT / PASSED / PLACEMENT FOR THE AY 2016 -17 (SOURCE: AICTE)[3]

Sr No.	Discipline	Intake	Enrolment	% Enrolment	Placement	% Placement
1	Chemical Engineering	36190	20883	57.7	6275	30
2	Civil Engineering	507664	261589	51.53	54104	20.7
3	Computer Science Engineering	587244	320081	54.51	112712	35.2
4	Electrical Engineering	442296	215083	48.63	69120	32.1
5	Electronics and Communication Engineering	556236	233825	42.04	100383	42.9
6	Mechanical Engineering	802484	422992	52.71	144363	34.1
7	Textile Engineering	12445	6358	51.09	2201	34.6
	Total:	2944559	1480811	Avg.: 51.17	489158	Avg.: 32.8

Shinde.et.al. has made an attempt to find the root causes of students and staff problems in technical education[4]. Attempt was made by Sahu.et.al. for identifying the key factors affecting the Effectiveness of Technical Education[5].Accordingly he suggests Infrastructure, Teaching Effectiveness, Extra Curricular Activities and Research and Development as the four major factors controlling the effectiveness and suggested the mathematical model to quantify it. Damayanti Sen shared experience regarding Indian technical education since independence, and shared views regarding tremendous efforts taken by government for improving the quality of education.[6]

Total quality management is the basic tool which many authors have adopted by some means or other as per requirement to enhance the effectiveness, efficiency excellence in technical education[7][8].

Government of India, AICTE, Ministry of Human Resources and Development (MHRD) are revising the policies time to time for quality improvement of the technical educations. Many monitoring committees like National Assessment and Accreditation Council (NAAC), National Board of Accreditation (NBA) are made mandatory to the institutes for grading. However the ground reality from the stakeholders – students, Faculties, parents and employers is too revived. An initiative is taken to enhance the productivity in higher (technical) education to ensure the quality of engineering graduates to be employable and support Skill Make in The survey is being done to analyse the problems in-depth from the different stake holders.

III. OBJECTIVE

- The objective is to merge the gap between Industry and Institutes.
- To enhance teaching learning process, by providing Outcome based education.
- To solve Psychological problems of the student as well as society using YOGA session at SANDIP university, Nasik.
- The objective of education would be performing based on cutting-edge curriculum in developments, offers a powerful way to face upcoming youth to be deliver for next generation societies.
- Reforming and managing with current era of fast growing network in the societies.
- The emphasis on quality based with higher maturity as well as technical skills to survive in future generations.

IV. METHODOLOGY / EXPERIMENTAL SETUP

The study is based on the data collected through survey of students from Second year to Final year of four years Engineering Programme, from the different Engineering Institutes from two Universities in Maharashtra, India. The open ended questioner was given to students, and the data was collected from nearly 438 students. Out of which 13 students feedback was not considerable/Blank. The data was shorted for further processing.

A. Analysis of the sample

The survey was planned for 500 students, out of which the response was from 438 students. Each respondent answered only one questionnaire. Multiple parameters were reflected from single response.

B. Characteristics of the respondents

The respondents are characterize in terms of their semester/year of the course, Branch, Institute and University.

C. Analysis of Data

The main purpose of the initiative to enhance the productivity in higher (technical) education was revealed from the analysis of the data collected. The analysis made it easy to categorize the student's feedback into thirteen main characteristics to be focused for enhancing the technical education:

1. Academics
2. Industrial Visits/ Seminars/ Workshops/ Events/ Value Added Programmes.
3. Innovation/R&D
4. Professional Languages/ Communication Skills
5. Counselling/Psychological/Human: Mind and Body
6. Technical
7. Sports
8. Infrastructure
9. Time Management
10. Industry/Site Sector
11. Caste
12. Financial -Cost/Fees/Rural
13. Business/Entrepreneur/ Employability.

V. RESULT AND DISCUSSION

In today's era, education is the foremost important to enhance productivity in the students for technical world.

- The primary aim is to identify the root cause of failure of the engineering education system to make graduates employable.
- It aims to support the Make in India, YOGA day and Skill India initiatives of Indian government, by providing Industry ready and highly skilled manpower to increase manufacturing in India.
- This aims to establish the relationship between teachers, scholars, and other educational leaders so that they can promote citizenship in free societies.
- It aims to attract more number of students to technical education by increasing employability, by initiating start-up's, by doing research and innovation for building Nation.

We have introduced the new concept to cope up with work culture of education system. Herein, we defined the probability indexes that have directly influence rating of the students-teacher relationship in technical education system.

We introduced the generalize formula based on probability index to solve this Academics and its core values which directly influence on the students, equation no. 1. Moreover, on this case we conducted practical approach with ≈ 438 students to solve this tedious problem for technical education. However, the rating has been done on the basis of averages.

Higher the weightage, higher number given “A” with decreasing order of purely English alphabet respectively. This capsule decided the basic function for technical education in previously mentioned application.

$$H = \frac{[(\mathrm{k}-\mathrm{n})x_n \;+ \sum_{n=1}^{k} x_{n+1}]}{2(\mathrm{k}-\mathrm{n})} \tag{1}$$

H = Function of Probability index

K = number of parameters (13 in this case)

n = integer (non-zero positive)

x = mean average

TABLE II. PROBABILITY INDEX FOR TECHNICAL EDUCATION SYSTEM

Sr No	Paramters	No. of Responses	Probability Index														Rating
1	Academics	642	1.4658													1.47	A
2	Industrial visits/Seminars/WS/ Events	160	0.3653	0.9155												0.64	C
3	Innovation/ R & D	36	0.0822	0.7740	0.2237											0.36	D
4	Professional Languages	7	0.0160	0.7409	0.1906	0.0491										0.25	E
5	Counselling / Psycological/ Human: Mind and Body	10	0.0228	0.7443	0.1941	0.0525	0.0194									0.21	F
6	Technical	5	0.0114	0.7386	0.1884	0.0468	0.0160	0.0171								0.17	H
7	Sports	7	0.0160	0.7409	0.1906	0.0491	0.0194	0.0194	0.0137							0.15	I
8	Infrastructure	10	0.0228	0.7443	0.1941	0.0525	0.0365	0.0228	0.0171	0.0194						0.14	J
9	Time Management	25	0.0571	0.7614	0.2112	0.0696	0.0137	0.0400	0.0342	0.0365	0.0400					0.14	J
10	Industry / Site Sector	5	0.0114	0.7386	0.1884	0.0468	0.0160	0.0171	0.0114	0.0137	0.0171	0.0342				0.11	K
11	Caste	7	0.0160	0.7409	0.1906	0.0491	0.0342	0.0194	0.0137	0.0160	0.0137	0.0365	0.0137			0.10	L
12	Cost/ fees/ Rular	23	0.0525	0.7591	0.2089	0.0674	0.0137	0.0377	0.0320	0.0342	0.0377	0.0548	0.0320	0.0342		0.11	K
13	Business / Entreprenuer	5	0.0114	0.7386	0.1884	0.0468	0.0907	0.0171	0.0114	0.0057	0.0171	0.0342	0.0114	0.0137	0.0320	0.09	M
	Probability Index		0.17	0.76	0.20	0.05	0.03	0.02	0.02	0.02	0.03	0.04	0.02	0.02	0.03	3.94	
	Rating		H	B	G	N	P	Q	Q	Q	P	O	Q	Q	P		

The table II shows that the maximum probability index is for Academics, then for Industrial visits. The academics parameters are evaluated separately for the further analysis. With through examination and evaluation the corrective measures and changes to be suggested in business model to increase the productivity of the system.

Focusing on parameter no 5 in the table 1. i.e. Counselling / Psychological/ Human : Mind and Body, the solution is suggested to implement Yoga practice for the students.

Funding agency – Sandip University.

Human mind basics need to correlate with some yoga technique such as Suryä Namaskar, chanting OM. This is a nice technique to relax human body and mind. This would enhance internal energy of the whole body. Although, we know from the law of nature that the universe contains infinite amount of energy, to regain that energy in human body chants OM, which interconnect with mind system and the universe.

Considering this the Yoga sessions are regularly organised in Sandip University as a part of case study. Fig. 1 shows students performing Yoga session.

Fig.1: YOGA PRACTICE IN SANDIP UNIVERSITY, NASIK.

VI. CONCLUSION

This is the fundamental tools to enhance productivity in Sandip University, Nasik which might be useful in student and teacher relationship. We have followed basic concept of the probability index. On this basis, the rating are given that would be more faithful as a case study i.e. practical approach to solve this issue. Also, to solve the Psychological needs of the students make a habit's of YOGA practice regularly which is useful to enhance basic needs of the Human: mind and body.

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Yog Nidra: a therapy to control human mind and body

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***Abstract* - An initiative has been performed in the Sandip University, Nasik for all students as well as faculty members. In the present study, earlier we have performed trials on 150 students whosever doing Yog Nidra for curing diseases. This might be useful to increase human body immune system and powerful tools to get rid of anxiety under going to present study which correlated with subconscious minds.**

Keywords— Yog Nidra, Meditation, Yogic Sleep.

I. INTRODUCTION

The basic capsule of Yog Nidra is same in historical background whereas Hinduisms and Bhudisim are aware of this technique. The Lord Kirsna often associated with Yog Nidra. This might useful for headache, giddiness, chest pain, palpitations, sweating and abdominal pain which respond well. It might useful for soldier having stress disorder in War[1].

Yog Nidra or Yogic sleep is powerful meditation technique. The practitioner has to lie down on back and rest in Savasana (corpse pose). It takes you to pancha maya kosha (five layers of self) with a sense of wholeness. Children to seniors at any age can practice this. Time is not the limit, it can be as short from five minutes to as long as one hour. It promotes deep rest and relaxation, calms the nervous system[2,3].

II. EXPERIMENTAL DETAILS

The study is based on the data collected through survey of students from Second year to Final year of four years Engineering Programme, from the different Engineering Institutes from Universities in Maharashtra, India. The open ended questioner was given to students, and the data was collected from nearly 500 students. The data of 150 students was shorted for further processing.

A. Analysis of the sample

The survey was planned for 500 students, out of which the response was from 430 students. For the topic enlisted above the sample of 150 students was analysed.

B. Characteristics of the respondents

The respondents are characterize in terms of their Branch, Institute and University.

C. Analysis of Data

Based on the parameters analysed from the database created from the students' survey, the focus is on the parameter Counselling/ Psychological points raised by the students. In regards to this the solution was proposed to organise Yoga sessions to the students. Few students were analysed for practicing Yoga. The focusing of the raw data is in the term of Counselling / psychological problems. Yog Nidra which directly related to Mind, Brain and Body. The five senses are key to generate feelings and emotions. However, during the thernastic application to cure Depression, Cancer whereas Yoga science is important tools for therapeutics treatment of tumour. So, for the analysis, we have taken importance of raw data of Counselling/Psychological/Yog Nidra.

III. RESULT AND DISCUSSION

We have performed Yog Nidra for the 150 students in the Sandip University, Nasik, India. However, students have been suffering from Depression, Anxiety, hypertension, hypothyroidism, or poor sleep. The basic needs used to reduce blood pressure, reduce stress, and improve sleep. The Yog Nidra has performed for students to cure anxiety, Hypertension and poor sleep for 45 min duration. During the Yog Nidra, the different types of the activities have been performed to relax Mind, Body and Brain. When we performed the test key parts of Brain network is activated to draw attention of Neural network. As we Know that King of the Body is Mind so there would be channelize the network of the body with Mind. This technique would increase Concentration, Confidence and bring joy as well as successes in Life.

IV. CONCLUSION

This is fundamental concept which are using ancient point of view to cure diseases. A perfect coordination between these three things is happening during Yog Nidra. The students get to finish their basic needs in life and they have become fully confident, empowering the new goals and increase in their Concentration during examination. The present case of study is cause new successes to the Students of the Sandip Universities, Nasik, India.

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Review of Indian Education System

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***Abstract*— In today's world of globalization, Indian education system is to be upgraded. The paper focus on the recent literature available related to teaching learning approach. The attempt is to analysis the admission condition in technical institutes due to growth in intake of seats. The fish bone diagram technique is suggested to analysis the root cause of failure, considering student as one of the stakeholders related to education system.**

***Index Terms*— Education system, Root cause analysis, Fish bone diagram**

I. Introduction

Technological improvements has accelerated the economic growth in Indian. Science and Technology plays a crucial and major role in economic development. India is equipped with huge number of youth manpower. Proper education will play a major role in guiding the youth and hastening the economic growth by providing skilled persons, speeding up the country's industrial development. Continuous research is going on for improvement of all the aspects of the education. It covers teaching learning process, staff and student's assessment/grading, teaching tools, industry institute interaction and many more.

Enhancing Teaching Learning: Research in academics is based for evaluation of staff and students or based on different learning approaches. Few are discussed in detail. A triangular prism model (TPM) is used to examine online learning communities (OLC) by Jared in USA[1]. But explanation of context, time and transformation process is missing. David et al. has proposed a Synthesis and Design Studio (SDS) model for engineering education over the traditional method of teaching learning[2]. A workshop on simulation tool for process control education was suggested by Yechun[3] and case studies were conducted. All these researches focuses on the academic course related contents and the way to enhance the teaching learning scheme. Mohammad and Elina suggested a framework for measuring quality in higher education with regards to teaching aspect only. Dimensions like academic resources, competence, attitude and content where the key elements analysed[4]. Social media trend is increasing now-a-days. Effective use of E-learning and M-learning has high impact on higher education[5]. A teaching model developed based on information technology – applied instructions increased the learning effect as compared to traditional methods[6]. Use of e learning and ICT as a mode of instruction has tremendously increased as it offers flexibility of anytime, anywhere access to interesting topic at low cost effectively[7]. In spite of advantages of e technology, there are few challenges and drawbacks which are to be addressed. Government has to play a crucial role to provide infrastructure in this transaction phase of Indian education system[8]. Reddy discusses certain drawbacks and challenges of using ICT[9].

Integrated strategic framework for engineering education is suggested by Anthony[10]. He highlights three domains engineering science, design and commercialization.

Lot of research is going on the teaching learning methodology and theories of teaching and learning.[11][12]. There are many institutes to evaluate/grade the teachers and students[13].Faculty performance assessment system using ontological model is suggested by Samita Bai[14].

Industry institute interaction in form of industrial visits, mini-projects, internships, major projects, placements, apprenticeships, etc. plays major role in teaching process[15].

Indian education system needs to undergo changes in order to sustain in globalized market. Mahadevi Banad et al. had discussed the challenges faced by the education system[16].Considering weakness of Indian Education system, where the parameters like rigid curriculum learning process, exam oriented system, lack of multidisciplinary courses, role of teacher, student and parents, industry-institute interaction and many more, there is need to implement strategic approach in Indian education system. But the focus on above mention parameters is missing.

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Similarly, there are many literature which describes the ways to access the students learning and grading[17]. But the strategic model to evaluate the teaching learning process considering Students, teachers, employers and other stakeholders involved in education system, is missing.

II. ENGINEERING EDUCATION IN INDIA

There is huge demand for technical education. As per recent report 18.86% of students are going for technical education as their under graduate study. To improve the quality of present technical education in India, Prof P Rama Rao, ARCI, suggested the need for a policy framework[18].

The grants from state and central government is the main source of funding for public universities and colleges, as compared with a small percentage from fees. It is observed that in Indian education many higher education institutions are underfunded, especially in the technical sector, where labs and classrooms are often under resourced and understaffed.

Growth of intake in Technical institutes in the country is shown in Table 1-[19]:

TABLE I. GROWTH OF INTAKE OF TECHNICAL INSTITUTIONS IN THE COUNTRY (UG)

Year	Engg	Phar	Arch	HMCT	Total	Added in Year
2006-07	659717	76030	5085	5840	746672	30432
2007-08	701214	77582	5189	5959	789944	43272
2008-09	753910	78763	5268	6050	843991	54047
2009-10	1093380	80370	5375	6174	1185299	341308
2010-11	1219347	81594	5457	6268	1312666	127367
2011-12	1386083	83041	6894	6295	1482313	169647
2012-13	1565722	85461	8874	6355	1666412	184099
2013-14	1634596	86444	8614	6520	1736174	69762

A boom in the number of technical institutions for engineering sector has led to acute issues and concerns. Colleges are struggling to hire adequately qualified faculty, whereas graduates are failing to find employment and regulators are under pressure to improve standards.

Uttar Pradesh has around 306 engineering colleges and 1.26 lakh+ seats were offered through common counselling seats in various government aided, private and government aided-self financed colleges last year. While the top engineering colleges including government institutions were able to fill their seats, the average and lesser known colleges have been left in the lurch.[20]

TABLE II. VACANCY POSITION IN ENGINEERING INSTITUTES

Type Of Institute	Total Seats	Total Allotted Seats	Vacant seats	%age of empty seats
Govt./Aided Self Finance	1338	1338	0	0
Other University	2280	1856	424	18.59
Govt. Aided College	3017	3017	0	0
Private College	120249	19936	100313	83.42
Total	**126884**	**26147**	**100737**	**79.39**

58 engineering colleges in the state of Uttar Pradesh ended up with no seats filled situation which accounts for nearly 20% of the total colleges, whereas 187 engineering colleges saw 1% to 20% of total seats filled. Thus collectively over 245 colleges saw less than 20% admissions.

Data shows that, private institutions accommodate 97% of 10,60,000 annual intake of students. The annual intake of students in all Indian Institute of Technology is 7,500, National Institute of Technology 35,000 and the rest i.e. 10,17,500 is accounted by the private institutions. This, highlights the dysfunctional accreditation process, resulting in lowering of quality of engineering education. It is need for strengthening the process to improve the quality of technical education.[20]

Comparing the number of engineers graduating in a year, at different levels for India and the USA, Dr Rao indicated that only 5% of the Bachelor degree holders from India go for the Masters degree whereas the corresponding figure for USA is about 50%. The total Ph.D. degree holders in engineering discipline in India for the year 2009-10 is only 1500 whereas for USA it is 7500. The Indian students should be made more competent to international level to go for higher qualification and research work. [18]

In 2002, a five-member committee headed by U.R. Rao, a prominent scientist and former chair of the India Space Research Organization, was established by the Ministry of Human Resources Development (MHRD) to review the performance of the AICTE. Submitted to the government in September 2003, the committee's report, Revitalizing Technical Education, describes a technical sector that is expanding at an unsustainable level and is in drastic need of regulation to ensure academic standards are improved. Following are few of the recommendations from the report[18].

- Many number of institutions due to unregulated growth, mainly in the private sector
- Faculty qualification not enough, and not nearly enough doctorates coming through the system
- Weak quality-assurance structures, especially accreditation procedures
- Lack of interaction and cooperation between classroom and industry.
- In engineering graduates high level of unemployment and underemployment is been observed.
- Economic growth rate is not matching the graduate growth rate.
- Colleges are not meeting the skilled manpower needs of industry

Facts and figures shows that in spite of demand of trained manpower, students are not turning to technical education. There is need to analyze the engineering education system and enhance the teaching learning process. Many UG students are not capable to meet the need from industries without finishing school or additional courses.

Considering the scenario of the Engineering institutes and the demand from the industry there is need to develop the strategic model for the Engineering education in India. Inspite of providing good infrastructure and faculty, the students are not been enrolled. There is need to measure the missing parameters of the institute.

III. Objective and Methodology

Objective of the research is to find root cause of failure at every possible location in education system. Methodology used will be Fish bone diagram.

The study and survey will be conducted to understand the effect of each and every parameter like Student, Teacher, Parent, Society and Employee. There are many factors like quality of student & teacher, teaching learning scheme, syllabus, examination pattern, family background, expectations of the employee from students to be employable, etc. these are to be classified properly and root cause analysis is to be done.

Sample Fish bone diagram for finding the failure causes related to student is suggested in fig.1

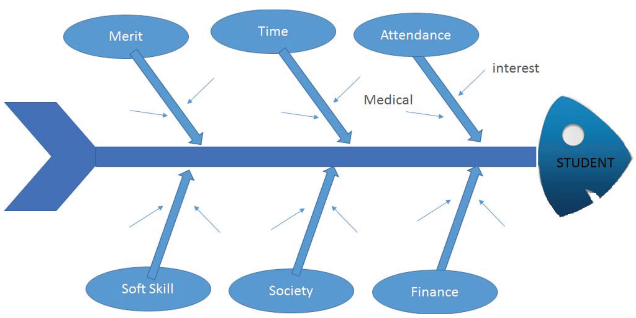

Fig. 1. Fish bone diagram.

IV. Conclusion

The scenario of the increase in technical institutes and drop rate of the students is the alarm situation for private institute. The efforts are to be taken to evaluate the institute and take corrective action to improve the pit falls. Root cause analysis will help the institute to find remedies for the lacunas.

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Ranking of Total Productive Maintenance pillars using Analytical Hierarchy Process

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***Abstract*— Total Productive Maintenance (TPM) is widely being used in industries for manufacturing excellence. TPM is based on eight pillars. Successful Implementation of TPM depends on in-depth knowledge of these pillars. The purpose of the paper is to understand the importance of these pillars mutually in terms of Quality, Cost, Delivery in time and Productivity (QCDP). In this work, ranking of TPM pillars is done with a questionnaire-based review by using Analytic Hierarchy Process (AHP), a multiple criteria decision-making (MCDM) methodology. A pairwise comparison of TPM pillars is done by survey considering a case of automotive industries in India. Ranking of TPM pillars is proposed to guide the management to decide the weightage of each pillar in terms of the major factors to improve Overall Equipment Efficiency (OEE). This in terms will guide them to give proper preference and allocate fund at proper time to proper pillar. The ranking suggested suites for automotive sector and assembly lines. By varying the judgemental rating according to type of industrial sector the new ranking can be obtained from the suggested guidelines on similar basis.**

Keywords*— *Analytical hierarchy process (AHP); Total productive maintenance(TPM); TPM pillars

I. INTRODUCTION

In today's competitive world, it is a great challenge for industries to achieve World class excellence. To cope up with the globalized economy, manufacturers are facing stiff competition. It is a tedious task to produce maximum with minimal resources and finances available, with eminent quality and timely deliverance. Proper production planning and timely maintenance with zero defects can cause the system pull through. Proper implementation of Total Productive Maintenance (TPM) will lead the industries towards manufacturing excellence.

TPM is based on eight pillars with the foundation of 5S (Sort, Set in order, Shine, Standardize, and Sustain)[1]. It is not an easy task to understand and implement TPM, as if a set of standard procedures which, when implemented will give the results[2]. TPM is widely used to improve effective use of equipment's and to obtain world class manufacturing system in terms of Quality and Cost[3]. Successful implementation of the TPM is a team work in which individuals from each and every department should work together, it is employee focused. Due to experience and expertise operator knows more about his machine and process. In most of the case studies, barriers in implementing TPM are discussed[4][5]. It is reflected that successful implementation of TPM is difficult without the support of top management. Financial constraints are more important as per the management is concerned. If management is convinced properly, then the major hurdle in the TPM implementation will be taken away. To merge the gap it is needed to present the analytical approach, to formulate a quantitative analysis of the TPM process to focus on the most important pillar. Top management can lead discussions as per budgetary provision or can allot extra fund for TPM implementation. Detailed review of the Industries shows that only some of the areas are being focused. Survey in Indian industries reflects the limitations of TPM implementation[6]. It is mainly due to lack of knowledge and fear of investments in terms of returns.

Considering all these factors, it is important to identify the priority of the TPM pillar analytically so that the management is convinced to implement the changes step by step and monitor the returns and see the improvement in OEE to make the industry to achieve world class excellence[7].

This paper thus proposes ranking of the eight TPM pillars, as per their significance in terms of four major parameters Quality, Cost, Delivery in time and Productivity (QCDP). A pairwise comparison is done showing their hierarchy, by using Analytic hierarchy process (AHP). AHP makes it possible to assess the criteria's based on the experience [8]. Based on the survey conducted in Indian industries, the ranking of pillars is made in hierarchical order. This makes it easy to focus on the particular task of comparatively higher priority and the judgmental forecast can be done with saving plans. As per hierarchy of pillars, priority can be given to the critical maintenance activities, with optimum use of the resources, which will increase Overall Equipment Efficiency (OEE).

II. LITERATURE REVIEW

TPM plays vital role in making the industry world class, measured by Overall Equipment Efficiency (OEE). TPM kick-off takes place in many industries but very few are able to successfully implement it. To the best of author's knowledge, most of the literature discusses the failures due to improper implementations of the TPM. Review of TPM implementation in the Indian Service sector shows a tendency of people react to implement new things, approach of top management to curb down the budget for several activities, problem of purchase and replacement of material, visionary approach and management support, are some of the factors bearing on effective implementation of TPM in Indian industries[7].

Significant review of TPM implementation in Indian industries is addressed by Ahuja & Khamba[1][9], Gupta and Vardhan[10]. TPM initiatives in steel plant, highlights how TPM implementation improved the production facilities in terms of four major criteria's – QCDP. In typical Indian industry, holistic approach for TPM needs to be implemented successfully. Team work, motivation and continuous improvement are necessary factors for positive results.

It is discerned that Indian industries are facing challenges because of many reasons like – sluggish response to change with the current market scenarios, traditional organizational structure, low quality and productivity, lacking in employee skill, education, motivation and safety, low automation, more wastage, failure to delivery in time, costumer complaints, taxes and infrastructural lacunas. According to Attri[5] et al. barriers to implementation of TPM in Indian industry can be classified as : Behavioral, Technical, Human and Cultural, Strategic and operational. Whereas Ahuja[4] has classified the barriers as : i) Organization – inability to change managerial & cultural approach, inability to convince unions, wrong focus on TPM, improper communication from top to bottom, ii) Cultural – resistance to change traditional approach, lack of consistency, iii) Behavioral - resistance from employees to adopt new changes, iv) Technological – little effort to improve design, reliability, lack of training and skills, v) Operational – acceptance of high rejection, lack of implementing standard procedures, absence of planned maintenance, vi) Financial – additional fund required in beginning to implement TPM, financial constraints from top management. vii) Departmental – poor team work.

For successful implementation of TPM it is important to find proper hierarchy of TPM pillars with respect to QCDP.

This can be done through pairwise comparison by Multi Criteria Decision Method (MCDM). Martin et al.[11] summarized various MCDM methods with its application. AHP suits for ranking the pillars, as pairwise comparison between the pillars with respect to the criteria's can be easily done. Lot of improvements are been done through TPM in Indian industries by using AHP. But only the importance of TPM verses Traditional maintenance system (TMS) is analyzed[12]. Similar attempts are being made by other researchers to justify TQM by using AHP[13]. Proper application of AHP or any other analytical method for hierarchy of TPM pillar is missing.

Use of AHP is found in various Production/manufacturing applications, N. Buyurgan presented a framework in advanced manufacturing[14], Madu implemented it for improving maintenance float system[2]. Ishizaka and Labib described its use for process ordering method[15]. This technique is applied in many areas social, personal, education, engineering, manufacturing, banking, sports, government[16] and many more fields and showed good results. No attempt has been made to use it for TPM. Attempt has been made to rank the TPM pillars by using AHP.

III. BACKGROUND

Brief regarding the TPM pillars and AHP process is given herewith:

A. TPM Pillars: Abbrivations used

TPM pillars and abbreviations used are shown in Fig. 1

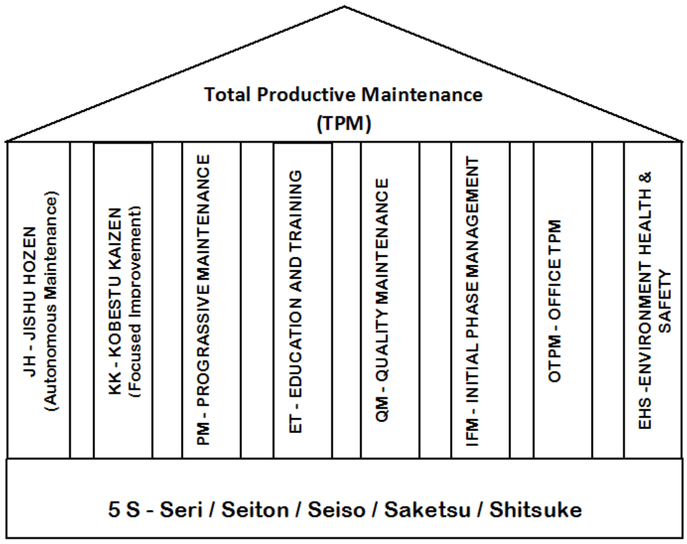

Fig. 1. TPM Pillars

TPM is based on eight pillars with a base of 5S. The goal of 5S is to create a clean and well-organized work environment.

Pillar 1: JH is mother pillar. It brings the ownership approach in the operator. Cleaning and maintenance is taken care by the the operator himself.

Pillar 2: KK aims to identify and minimize waste, quality and manufacturing losses. Elimination of losses helps improving OEE.

Pillar 3: PM pillar deals with Preventive break down (Time Base Maintenance). It establish Preventative and Predictive Maintenance systems for equipment and tooling. Effectiveness of maintenance department is increased to the point where 8 big losses are not generated.

Pillar 4: ET boost the moral and expertise of the operators and persons involved by to providing soft skill training and technical training.

Pillar 5: QM pillar monitors the factors affecting variability in product quality. It focus to accomplish zero quality defects.

Pillar 6: IFC establish systems to shorten new product or equipment development prototyping lead time. Achieve stable commissioning of new product and equipment vertical start up.

Pillar 7: OTPM goal is to achieve zero functional losses, create highly efficient offices and provide effective service and support to other departments. Administrative and support departments can be seen as process plants whose principal tasks are to collect, process, and distribute information. Process analysis should be applied to streamline information flow

Pillar 8: SHE Assures safety and prevents adverse environmental impacts which are important priorities in any

TPM effort. EHS achieve and sustain zero accidents, creates healthy, rewarding and pleasant workplace.

B. Analytic Hierarchy Process

Analytic Hierarchy Process (AHP) was developed by Thomas L. Saaty in 1970's[8]. It is used for multi criteria decision making in which the factors are arranged in a hierarchic structure. An advantage of the AHP over other MCDM methods is that AHP is designed to incorporate tangible as well as intangible factors, especially where the subjective judgments of different individuals constitute an important part of the decision process.

A pairwise comparison method is used to calculate relative values between each TPM pillar with respect to each other for four criteria's QCDP. A scale of judgments ranging from 1 to 9 (equal to extreme) is used for rating.

The methodology of AHP consists of following steps[17]:

Step 1: Statement of Problem having Attributes and Criteria.

Step 2: Represent problem in form of tree.

Step 3: Pairwise comparison of alternatives

Step 4 Formation of square matrix of above comparison.

Step 5: Normalization matrix is formed from eigenvalues and eigenvectors (weights)

Step 6: Check Consistency of the matrix by calculating the Consistency Index, CI. The value of CI should be less than 0.1 as recommended by Saaty.

Step 7: Obtain local & global ratings.

Step 8: Priorities or overall goal.

IV. OBJECTIVE

The objective of the research paper is to rank TPM pillars in terms of their importance in contributing to the factors QCDP of Industrial excellence using AHP developed by Thomas L. Saaty[8] for the excellence of Indian industries. Pairwise comparison of each pillar considering each criteria is done. Influence of Moral and Safety is equal with respect to each pillars, there contribution is not significant as compared to other criteria's. So analysis is carried out by considering QCDP criteria's only.

This research is based on providing the best possible solution with an analytical approach to the present theoretical concept of TPM. The study focuses on Indian industries where the TPM is not effectively implemented. During the survey for ranking of the pillars, it was clear that the TPM kick off takes place, but it is not implemented properly and over a period of time it stops. Failure occurs due to one or more constraints and barriers as discussed. The main reason is involvement of management and availability of fund for implementing the things at right time in right place. If the management is convinced by proper grading of the pillars it will be easy to allocate the fund at proper time. Ranking will give the proper focus and set the priorities for the budget. This will help in successful implementation of TPM, in terms increase in OEE.

V. METHODOLOGY

A survey was conducted based on the questioner using 9 point rating scale of Saaty for AHP[8]. Companies from Automobile and assembly sectors were considered for the survey. Following points were considered while selecting the company for survey:

a) The industry should have 5S culture, ensuring environmental cleanliness, safety and comfort. Thus the role of the criteria's Safety and Moral shall not be reckoned in determining hierarchy based on QCPD.
b) This will be more rational if the Industry happens to be an engineering Industry of Assembly type instead of a Process plant where dust and contamination of air, water etc. is dominant.

A. Collection of Data

Analysis is based on the data collected from Indian industries. As a part of research methodology the paired comparison data is collected in consultation with the management representatives of some companies or other persons responsible for TPM implementation. The management representatives have overall responsibility of TPM planning and implementation and they are appointed by the CEO of the company. Apart from them, consult of various pillar heads of the industry are taken to make the data more authentic. Each of these pillar heads is an experienced senior manager aware of all the pillars and their impact on QCDP. A questioner is designed based on 9 point rating scale for AHP.

B. Ranking of TPM Pillars

Analytical Approach: A study of literature on TPM reveals that most of reported information describes the eight pillars in a QUALITATIVE manner without resorting to utilize mathematical modelling. Most of the literature available gives an account of how a certain industry applied TPM and achieved increased productivity, quality, etc. at reduced cost. It is almost a monotonous repetition of the eight pillars. There is a need to make a proper attempt to rank the pillars in a QUANTITATIVE way so as to be a helpful guideline for research into Total Productive Maintenance.

Analysis is carried out by using paired comparison of each of the eight pillars with the objectives: Quality, Cost, Productivity and Delivery on time. The paired comparison helps in calculating the relative score of each of the TPM pillars on the four criteria. Next the four criteria are compared with each other through paired comparison to find the weightage of each of the criteria. Finally, on multiplying the scores of the eight TPM pillars, the summed, weighted score of these pillars is calculated. This helps in identifying the most important pillar on the overall ranking.

C. AHP for Ranking of the pillars

For the objective to rank eight pillars of TPM with respect to their importance towards QCPD, AHP process is used to find the hierarchy of the pillars as follows:

1. Criteria and Attributes

For ranking of the TPM pillars, its eight pillars are criteria's and Quality, Cost, Delivery in time and Productivity (QCDP) are considered as attributes.

2. *Hierarchy of Decision*

The hierarchy of the attributes and criteria are shown in Fig. 2.

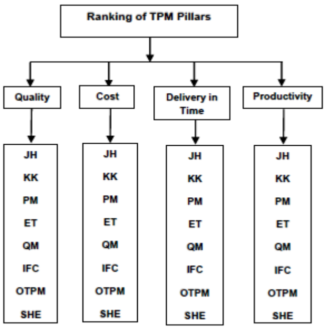

Fig. 2. Hierarchy of Decision

3. *Pairwise comparison scale*

Scale for AHP: Standard 9 point rating scale proposed by T.L. Saaty[18] is used for rating the pillars.

4. *Pairwise comparison matrix*

A questioner was generated to rate the pillars with respect to each other, sample shown in Table I. Nine point Linkert scale is used for rating the pillars with respect to each other.

TABLE I. SAMPLE VALUES FROM QUESTIONEER

Factor	Factor weighting Score - Quality																	Factor
	More important than								Equal	Less important than								
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	PM
JH	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	OTPM

Based on the ratings given a pairwise comparison matrix is prepared for each criteria. Table II shows rating of various pillars considering Cost as the criteria.

TABLE II. CRITERIA QUALITY: PAIRWISE COMPARISON

	JH	KK	PM	ET	QM	IFC	OTPM	SHE
JH	1.00	6.00	1.00	4.00	1.00	6.00	8.00	8.00
KK	0.17	1.00	0.50	0.50	0.50	1.00	6.00	8.00
PM	1.00	2.00	1.00	4.00	0.50	6.00	8.00	8.00
ET	0.25	2.00	0.25	1.00	0.50	6.00	8.00	8.00
QM	1.00	2.00	2.00	2.00	1.00	8.00	8.00	8.00
IFC	0.17	1.00	0.17	0.17	0.13	1.00	1.00	4.00
OTPM	0.13	0.17	0.13	0.13	0.13	1.00	1.00	4.00
SHE	0.13	0.13	0.13	0.13	0.13	0.25	0.25	1.00

Similarly, based on the data from questionner, matrix are obtained for other criteria. Table III, IV and V shows rating for Cost, Delivery in time and Productivity respectively.

TABLE III. CRITERIA COST: PAIRWISE COMPARISON

	JH	KK	PM	ET	QM	IFC	OTPM	SHE
JH	1.00	1.00	1.00	4.00	1.00	4.00	0.50	4.00
KK	1.00	1.00	1.00	6.00	1.00	6.00	1.00	6.00
PM	1.00	1.00	1.00	6.00	1.00	6.00	1.00	6.00
ET	0.25	0.17	0.17	1.00	1.00	1.00	0.50	1.00
QM	1.00	1.00	1.00	1.00	1.00	4.00	1.00	6.00
IFC	0.25	0.17	0.17	1.00	0.25	1.00	0.50	4.00
OTPM	2.00	1.00	1.00	2.00	1.00	2.00	1.00	8.00
SHE	0.25	0.17	0.17	1.00	0.17	0.25	0.13	1.00

TABLE IV. CRITERIA DELIVERY IN TIME: PAIRWISE COMPARISON

	JH	KK	PM	ET	QM	IFC	OTPM	SHE
JH	1.00	2.00	1.00	4.00	1.00	8.00	6.00	4.00
KK	0.50	1.00	4.00	6.00	4.00	8.00	6.00	6.00
PM	1.00	0.25	1.00	4.00	1.00	8.00	6.00	6.00
ET	0.25	0.17	0.25	1.00	0.50	6.00	4.00	4.00
QM	1.00	0.25	1.00	2.00	1.00	8.00	6.00	6.00
IFC	0.13	0.13	0.13	0.17	0.13	1.00	0.50	0.50
OTPM	0.17	0.17	0.17	0.25	0.17	2.00	1.00	4.00
SHE	0.25	0.17	0.17	0.25	0.17	2.00	0.25	1.00

TABLE V. CRITERIA PRODUCTIVITY: PAIRWISE COMPARISON

	JH	KK	PM	ET	QM	IFC	OTPM	SHE
JH	1.00	2.00	1.00	4.00	1.00	8.00	6.00	4.00
KK	0.50	1.00	4.00	6.00	4.00	8.00	6.00	6.00
PM	1.00	0.25	1.00	4.00	1.00	8.00	6.00	6.00
ET	0.25	0.17	0.25	1.00	0.50	6.00	4.00	4.00
QM	1.00	0.25	1.00	2.00	1.00	8.00	6.00	6.00
IFC	0.13	0.13	0.13	0.17	0.13	1.00	0.50	0.50
OTPM	0.17	0.17	0.17	0.25	0.17	2.00	1.00	4.00
SHE	0.25	0.17	0.17	0.25	0.17	2.00	0.25	1.00

5. *Normalization*

Table VI gives the calculations for normalization matrix for various pillars with respect to Quality as a criteria.

TABLE VI. CRITERIA QUALITY: NORMALIZATION MATRIX

	JH	KK	PM	ET	QM	IFC	OTPM	SHE
JH	0.261	0.420	0.194	0.336	0.258	0.205	0.199	0.163
KK	0.043	0.070	0.097	0.042	0.129	0.034	0.149	0.163
PM	0.261	0.140	0.194	0.336	0.129	0.205	0.199	0.163
ET	0.065	0.140	0.048	0.084	0.129	0.205	0.199	0.163
QM	0.261	0.140	0.387	0.168	0.258	0.274	0.199	0.163
IFC	0.043	0.070	0.032	0.014	0.032	0.034	0.025	0.082
OTPM	0.033	0.012	0.024	0.010	0.032	0.034	0.025	0.082
SHE	0.033	0.009	0.024	0.010	0.032	0.009	0.006	0.020

Normalization matrix for other criteria can be obtained similarly.

6. *Consistency Check*

Saaty[18] proposed that the consistency index should be less than 10%, if not the priorities does not make any sense and the judgements may need to be revised for various pillars with respect to Quality as a criteria. Consistency check is conducted after normalization matrix.

Table VII shows the Consistency check for the above normalization results.

TABLE VII. CRITERIA QUALITY: CONSISTANCY CHECK

	Weights	Products	Ratio
JH	0.2544	2.3963	9.4196
KK	0.0910	0.7891	8.6750
PM	0.2033	1.9168	9.4296
ET	0.1292	1.1859	9.1787
QM	0.2312	2.0604	8.9131
IFC	0.0416	0.3625	8.7180
OTPM	0.0315	0.2622	8.3282
SHE	0.0179	0.1498	8.3547
		CI =	0.1253
		CI / RI = 0.09	

As consistency ratio CR is less than 10% the matrix can be considered as having an acceptable consistency.

Similarly weightage are found for cost, delivery in time and productivity.

7. *Ratings*

After comparing all the pillars with respect to different criteria's, the criteria's are also compared with respect to each as per the priority. Weightage for QCDP are tabulated below. The comparison matrix for QCDP is in Table VIII.

TABLE VIII. PAIRWISE COMPARISM OF QCDP

	Q	C	D	P
Q	1.00	4.00	2.00	1.00
C	0.25	1.00	0.50	0.17
D	0.50	2.00	1.00	0.50
P	1.00	6.0	2.00	1.00

8. *Overall Goal*

Finally the percentage weightage are calculated in Table: IX. The graphical representation of the hierarchy obtained by AHP is shown in Fig. 3.

TABLE IX. SCORE OF THE PILLARS

Pillar	% Weightage				
	Q	C	D	P	Overall %
JH	25.44	15.18	11.44	21.43	**20.581**
KK	9.10	19.15	22.29	28.73	**19.903**
PM	20.33	19.15	19.31	16.92	**18.722**
ET	12.92	5.71	10.50	8.14	**10.048**
QM	23.12	15.28	13.96	15.51	**17.899**
IFC	4.16	5.29	5.82	1.96	**3.682**
OTPM	3.15	17.36	13.84	4.29	**6.620**
SHE	1.79	2.87	2.84	3.03	**2.545**

VI. RESULTS AND DISCUSSION

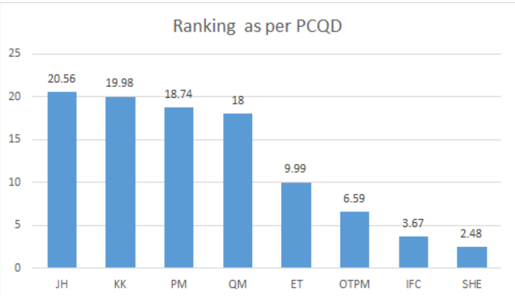

Fig. 3. Ranking of TPM pillars as per contribution towards criterias PCQD

In case of TPM implemented industries it can be seen that out of eight pillars JH and KK are used more number of times than other six. JH & KK pillars has the maximum weightage, with marginable difference. JH focus on improvement of Quality which enhances productivity whereas KK has high impact on Productivity by reducing various losses, increased production rate maintaining prompt delivery schedule followed by reduction in manufacturing cost. It is recommended to start implementing TPM with JH pillar followed by KK. After that the focus on PM & QM pillars. Once all these are in action, it will be enhanced with ET & OTPM pillar activities. IFC and SHE can be followed thereafter.

VII. CONCLUSION AND FUTURE SCOPE

The results obtained helps to categorize the pillars according to priority as: top priority (JH and KK), medium (PM and QM) and low priority (ET, OTPM, IFC and SHE). It will be easy for the managers to convince the top management and attract attention on the pillars with top most priority. However the results obtained will work for particular set of companies, it should not be treated as universal. The survey results are for automobile components manufacturing industries. According to the type of industries the rating can be varied and the new hierarchy can be obtained easily. For chemical industry top priority may go to pillar SHE, whereas for service industries it may be OTPM.

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Identifying Root Causes for Students Problems in Technical Education using Fishbone Diagram

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***Abstract*— Fishbone diagram is a tool used in Industries to identify the root cause of the problems. An attempt has been made in this paper to use this technique to identify problems in Engineering education system in India, considering student as the stakeholder. Major problems are classified and fishbone diagram is used to analysis the root causes of each parameter.**

***Keywords*— Fishbone diagram, Root cause analysis, Engineering education system, students problems.**

I. Introduction

The current imbroglio in the teaching and learning process depends on the three major stakeholders; which are staff, students and the methods used to teach. In this scenario, the every stakeholder plays an equivalent role in the success or failure of the system. Thus, looking at all the three parameters this paper has initiated to do the root cause analysis in one of the most interesting parameter i.e. students. This paper deals with the problems arises in the lives of student in this circle of technical (engineering) education system. Analysis of the problems is going to be done with the help of the fishbone cause and effect diagram.

This method proves to be effective in order to reach the root cause of some issue. In this process there are major parameters; which acts as the main points or as a general term of one compiled problem and then on which further sub-issues are discussed. For example: this skeleton of a fishbone diagrams depict the causes of the problem until its root cause.

The outcomes that we expect from this analysis are we will be able to identify the ultimate or the root causes faced by the students. In this way, we will be able to propose a common solution their problems and also suggests education (Indian) system to upgrade their policies and methods. This paper makes an effort to mitigate the flaws in the technical Indian education system thus, increasing its efficiency and strengthening its position in the global education scenario.

II. Literature Review

A. Fishbone Diagram

The Ishikawa diagram is a tool to recognize the root causes of quality imbroglios. It was named after Kaoru Ishikawa, a Japanese quality control statistician, the man who pioneered the use of this chart in the 1960's. The Fishbone diagram is a process of breaking down the known truths that provides an orderly way of observing at result and the reason that account for those effects. Because of the intention of the Fishbone diagram, it may be delegated as a cause-and-effect diagram by Watson in 2004. Fishbone (Ishikawa) diagram mainly represents a model of suggestive presentation for the correlations between an event (effect) and its multiple happening causes. The structure provided by the diagram helps team members think in a very systematic way[1].

Fishbone diagram is effectively used to reach the root cause of the problem. Some of the cases are discussed herewith. Jayswal et al. has used this to analysis of sustainable process of chemical/energy sector[2]. Quantification of risk assessment for FMEA analysis in processing industry[3].

Use of Fishbone in Educational sector is reflected in few cases. Reid[4] use this for categorising barriers of instructional technologies. Jih,Huang[5] used it for analysis of e-teaching. Use of 5why technique for questioning technique was done in Thiwan by Lu[6]. Problems in University colleges where analysed by Desai et al[7]. However the analysis is to be done in Indian perspective.

B. Scenario of Indian Engineering Education System

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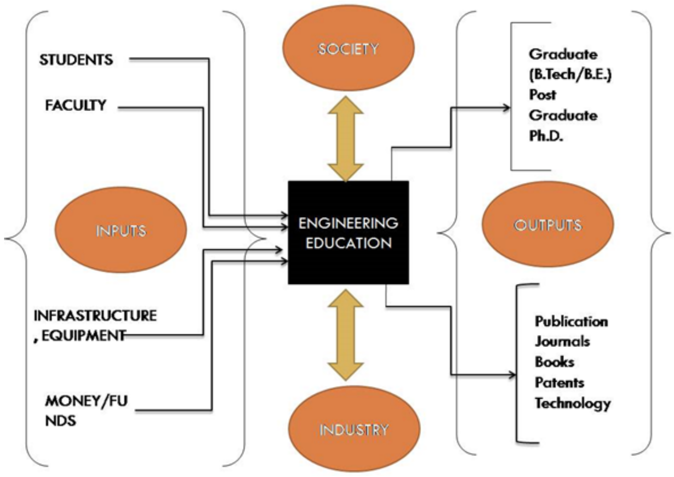

Fig. 1. Engineering Education in India[8]

The block diagram shown in Fig. 1 describes the Indian engineering education system. The four main stake holders are the society, industry, inputs and outputs. As engineering education is a professional technical degree which servers for four years course with many outcomes being either bad or good. The inputs are induced by students, faculty, infrastructure, money these are the factors which influence the engineering education system on a whole and further more joined by the society and the industry at regular intervals and all this resulting into the outputs shown in the figure namely the various degrees of graduation or the post graduation and the publications[8].

III. STUDENTS PROBLEMS WITH FISHBONE DIAGRAM

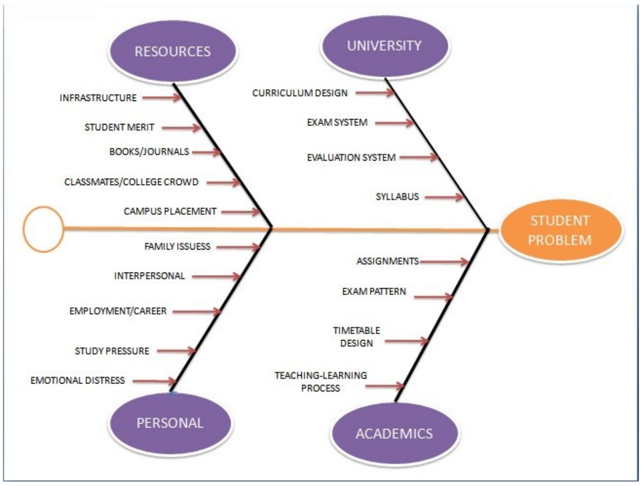

Fig. 2. Root Cause Analysis of Students Problems

The Fig.2 shows the root cause analysis of the student problems with the help of fishbone diagram. The main reasons are personal, universities, resources, academics. These main factors have sub-factors which takes us to the root cause of these problems.

A. Personal

Zhibin Chen reveals in his paper Psychological Problems and Countermeasures of College Students all the personal and psychological problems which a college student faces being in college. On further adaptation, the paper tells us that nowadays it's a very major issue in the college life to have these problems and many students are diagnosed with these disorders.

Zhibin jotted down few causes for these emotional unbalance in a student's mind. They were as follows: interpersonal tensions, Crises of employment and career prospectus, study pressure, Emotional distress, psychological expectations do not meet family, contemporary social impacts, inertia in inherent traditional educational models, family reasons, and traditional Chinese cultural factors. The above mentioned causes are relevant and do exists in the lives of student[9].

One more parameter that is to be considered is that there are no proper career councilors available for students to guide them in their journey to become a successful engineer. According to Lie Pan, Haiyan WU and Xun Wang career councilors say that access to information is the key to employment. There are various mediums to seek information like campus network, University Career Guidance Website, Job network, customized services. According to the authors student are keen to work and get employed but the only issue is they do not have the right platform to do so. They lack information and the seriousness of employment in the colleges while getting educated. Colleges should increase the propaganda of the employment issue right from the first year itself[10].

B. Academics:

The sub reasons that come under the academics as a stakeholder are as follows: 1. Assignments, 2. Exam pattern, 3. Timetable design, 4. Teaching and learning process. Now considering each pattern separately we get to know that the higher technical education demands the various assessments based to test a set of skill of a student on his problem solving skills, logic abilities, etc. The candidate has to solve these assignments and prove his worth in every assignment in order to get good grades in the term work grades and ace his exams. These assignments also reflect the student's capabilities to understand the topic. The assignments should be designed in such a way that they are good enough to test skills but not intimidate the student. However according to the author Rekha and Uma many a times home assignments are not taken seriously by the students and a lot of copying is involved thus making it unfair to grade their work[11].

Author as a student has an opinion that, students have an issue with assignments when excessive assignments are forced on them. To the point assignments which will reflect their abilities are considerable although just writing for the sake of assignments does no good. In the engineering education excessive assignments plays a key role in wasting the time of the student. However a good assignment if replaced with these unnecessary work; it will definitely help to improve the scenario of Indian engineering education. For this need of different technique to get the things done in more practical way is necessary, which can be done by Problem Based Learning (PBL).

Secondly, exam pattern is a very prime issue in understanding the difficulty to get good grades in the exam. Every student's perception of the getting adapted to the education system is different and also the estimated time for getting adjusted with the system may differ. This difference often results into the failure or a major setback for the student. Understanding the exam pattern is very important in order to write the exams. In universities over the time many patterns have changed which confuses the student to a larger extent. Students take time to understand exam pattern, which results in their gradation. They focus on scoring in exams but the actual conceptual study is missing. Thirdly, timetables play a crucial role in any academic system. A well designed timetable is always a key to more success stories in the engineering education. Timetables can be of exam as well as the daily scheduled lectures. Academic timetable should take care of basic workload as per the university guidelines, as well as it should take care of co-curricular and extra-curricular activities of the students. It should as well consider the time required for student upgrading and merging the gap between syllabus and present requirements from the recruiters. Both the timetables should be designed in such a way that they take care of all norms but are also student friendly, are designed by making student as the focus considering their study and work.

Lastly, another very important factor is the teaching-learning methods. Latest techniques of teaching-learning should be used like : PBL, e- Learning, ICT etc. In Indian education system traditional teaching method should be supplemented with these recent techniques for excellent results.

C. Resources

As like requirements of materials in industries, resources are required for education. One of the causes for student's failure is resources. This cause highlights the various shortcomings as college infrastructure, variation in students merit and tradition, books, journals etc.

The college infrastructure plays a vital role in the education of the students, if it's not well built than there will be obstacles in the overall development of the student. Some of the most basic necessary elements that a college campus should have are: well-equipped classrooms and laboratories, as the norms mentioned by the university syllabus. Library with sufficient books, journals, newspapers, magazines, e-library with access to online books and journals proves to be an important aid in education.

Classmates are also major reason for the student to be disinterested in the curriculum. If the college crowd is not good as in the students are not study oriented they affect the performance of the student as they might distract the student's focus from the studies and divert it elsewhere. This may happen if there is large difference in students merit during intake.

Campus placement also plays major role. Also access to industries through industrial visits, expert lecture series through industrial person, in-plant training, internship, projects is required for overall growth of the students. Some colleges fail to do so even they are advertising; this decays the moral of the students.

D. Universities

Role of universities is very important because the entire educational course is governed by it. Curriculum design is the most important parameter. Examination system and evaluation system also affects the output of the students. It should be taken care to match the syllabus with latest technologies.

IV. Results and Discussion

By using Fishbone diagram, it is easy to reach till the root cause of the problem. Four major aspects of the source of problems are identified and causes of the same are discussed

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An AHP Approach for Various Applications - Review Paper

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Abstract - **The foundation of the Analytic Hierarchy Process (AHP) is a set of axioms that carefully delimits the scope of the problem environment (Saaty 1986). It is based on the well-defined mathematical structure of consistent matrices and their associated right eigenvector's ability to generate true or approximate weights, Merkin (1979), Saaty (1980, 1994). The AHP methodology compares criteria, or alternatives with respect to a criterion, in a natural, pairwise mode. To do so, the AHP uses a fundamental scale of absolute numbers that has been proven in practice and validated by physical and decision problem experiments. The fundamental scale has been shown to be a scale that captures individual preferences with respect to quantitative and qualitative attributes just as well or better than other scales (Saaty 1980, 1994). It converts individual preferences into ratio scale weights that can be combined into a linear additive weight w(a) for each alternative a. The resultant w(a) can be used to compare and rank the alternatives and, hence, assist the decision maker in making a choice. Given that the three basic steps are reasonable descriptors of how an individual comes naturally to resolving a multi criteria decision problem, then the AHP can be considered to be both a descriptive and prescriptive model of decision making. The AHP is perhaps, the most widely used decision making approach in the world today. Its validity is based on the many hundreds (now thousands) of actual applications in which the AHP results were accepted and used by the cognizant decision makers (DMs), Saaty . Here we will see the review of the applications of AHP in various fields.**

Keywords - **AHP**

I. INTRODUCTION

A. Analytic Hierarchy Process

AHP is a mathematical technique used for multi-criteria decision-making. In a way it is better than other multicriteria techniques, as it is designed to incorporate tangible as well as non-tangible factors especially where the subjective judgments of different individuals constitute an important part of decision making (Saaty, 1980). Apart from other facts, this is rooted in the special structure of the AHP, which follows the intuitive way in which managers solve problems, and in its easy handling compared with other multi criteria decision-making procedures. Hence the intuitively solved decision problems can now be solved as procedure-orientated using AHP. The use of AHP leads to both, more transparency of the quality of management decisions and an increase in the importance of AHP (Ossadnik W& Lange O, 1999).

Because of its intuitive appeal and flexibility, many corporations and governments routinely use AHP for making major policy decisions. Applications of AHP can be seen in a wide range of areas like merit salary recommendation system (Troutt M D & Tadisina S K, 1992), environmental impact assessment (Ramanathan R, 2001), credit evaluation of the manufacturing firms (Yurdakula M & Tansel Y, 2003), indoor environment assessment (Chianga CM & Laib CM, 2002), selection of alternative transportation options (Yedla S & Shrestha RM, 2003), performance measurement system (Suwignjo P et al, 2000), TQM implementation (Chin K S et al, 2002), evaluation of highway transportation (Weiwu W & Jun K, 1994), determination of key capabilities of a firm (Hafeez K et al, 2002) and for evaluation of an AHP software (Ossadnik W & Lange O, 1999) itself.

AHP uses a five-step process to solve decision problems. They are

- Create a decision hierarchy by breaking down the problem into a hierarchy of decision elements.
- Collect input by a pair wise comparison of decision elements.
- Determine whether the input data satisfies a consistency test. If it does not, go back to Step 2 and redo the pair wise comparisons.
- Calculate the relative weights of the decision elements.
- Aggregate the relative weights to obtain scores and hence rankings for the decision alternatives.

One of the major reasons for the popularity of AHP is that the decision maker does not require advanced knowledge of either mathematics or decision analysis to perform first two steps (Karapetrovic S & Rosen bloom ES, 1999). Last three steps are computational and can be performed manually or using software such as Expert Choice. However, the first two are the steps where the decision maker is very much involved in the model. On the basis of the decision maker's understanding of the problem, the hierarchy can be designed and pair wise comparisons can be made of the decision elements. AHP uses redundant judgments for checking consistency, and this can exponentially increase the number of judgments to be drawn out from decision makers.

CASE 1 :
AHP Based Approach For Selection Of Measuring Instrument:

Research problem

Unprecedented growth in engineering education institutes in India in the last decade led to complex issues. The main issue was that of maintaining the quality of education provided by these institutes. Many reasons are pointed out as the cause of this situation. A study has been conducted to find out the quality issues of undergraduate engineering education sector. As the faculties of engineering colleges are the experts and one of the main stakeholders of engineering education, it is decided to collect their opinions and information as the key resource for the study. Obviously the opinions will be subjective, and based on multiple criteria. Hence AHP is adopted to analyze the problem.

The hierarchy designed for the present research problem includes, two levels of decision-making. Six alternatives are to be compared in the first level. The number of judgments for comparing alternatives in the first level will be 15 ($6c_2$). The second level contains a total of 19 alternatives coming under the 6 alternatives of first level. Number of comparisons at the second level will be 22 ($4c_2+3c_2+3c_2+2c_2+3c_2+4c_2$). Hence the total number of pair wise comparisons for the two levels will be 37. This is often a tiring exercise for the decision-maker. Design of a proper questionnaire for data collection is very important in this situation. This paper discusses the process of decision-making adopted for the selection of the best questionnaire from a number of alternatives.

Objective

To develop the best questionnaire for data collection for the pair wise comparison of =AHP method of prioritizing the quality issues of undergraduate engineering programmes'.

Methodology

Five types of questionnaires were developed for collecting the pair wise comparison of 'quality issues of engineering education'. Three criteria were considered while designing the questionnaire. They are easiness to fill up the questionnaire, clarity of questions and extraction of intended responses. The structures of the questionnaires with sample questions are given in the appendix. AHP is selected as the method of decision process.

Step 1: Formation of hierarchy

The decision hierarchy is formulated by breaking down the problem into a hierarchy of decision elements and given in figure 1.

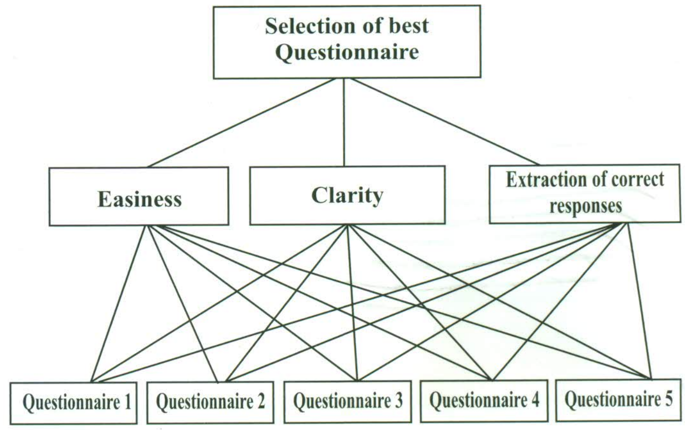

Fig.: 1 Hierarchy of selection process

Step 2: Collection of inputs

AHP is used as a tool for systematically analyzing the opinions of several experts belonging to diverse fields in this step. Consulting more experts will avoid bias that may be present when the judgments are considered from a single expert. Hence five faculties from five engineering colleges coming under five different states (Gujarat, Andhra, Karnataka, Tamil Nadu and Kerala) are selected as the experts for the decision-making. The nominal-ratio scale of 1 to 9 (Saaty, 1994) is adopted for pair wise comparison of the questionnaires.

All the five questionnaires were given randomly to the experts and requested to fill up the questions in all the five questionnaires. Then they were asked to conduct a pair wise comparison of the five questionnaires, and to rank them based on the three criteria easiness, clarity, and extraction of correct responses. All the five responses were collected and recorded.

Step 3: Consistency Test

The results of pair wise comparisons are filled in positive reciprocal matrices to calculate the eigenvector and eigenvalue (table 1 to 5). The consistency of the judgments is determined by a measure called consistency ratio (C.R.). The consistency ratio is obtained to filter out the inconsistent judgments, when the value of the consistency index (C.I.) is greater than 0.1. All the judgments are found to be consistent and accepted for analysis.

Steps 4 & 5 : Calculation of relative weights & ranking of alternatives

Geometric mean method has been the most widely applied method in AHP for aggregation of individual preferences when more than one expert is involved in the decision-making. Though all the expert opinions are consistent, the opinion of third expert seemed to be entirely different from others. He is informed of this variation and asked whether he wants to stick on to his earlier opinion or ready to modify the same to match with the others. The expert selects second option and the pair wise comparisons are modified accordingly. Geometric mean of individual opinions are calculated and entered in the final judgmental matrix for finding out the ranks of the alternatives. The judgmental matrix and the ranks of the questionnaires are given in table 6.

Results and Analysis

The priority vector indicates that Questionnaires 1 and 2 are equally good for data collection. Questionnaire 4 is also acceptable to the experts. Other options, especially the fifth one is totally unacceptable to the experts. It is clear from the rankings that a detailed and simple questionnaire is preferred to a compact and less time consuming method. Fifth questionnaire, though very simple cannot gather the required information of pair wise comparisons, and hence rejected by the experts. Third questionnaire is very compact but a novice user who is unaware of matrix structures will find it very difficult to fill it up. Hence the experts while taking decision neglect the easiness to the researcher for collecting and storing data. Based on the rankings given by the experts and through the discussions with them, it is decided to develop a modified questionnaire, which is a combination of first, second and fourth types.

Table 1: Opinion of Expert 1

	Q1	Q2	Q3	Q4	Q5
Q 1	1	0.5	2	3	2
Q 2	2	1	3	4	2
Q 3	0.5	0.33	1	0.5	1
Q 4	0.33	0.25	2	1	0.5
Q 5	0.5	0.5	1	2	1

Table 2: Opinion of Expert 2

	Q1	Q2	Q3	Q4	Q5
Q 1	1	0.33	5	3	3
Q 2	3	1	3	1	3
Q 3	0.2	0.33	1	0.33	0.33
Q 4	0.33	1	3	1	5
Q 5	0.33	0.33	3	0.2	1

Table 3: Opinion of Expert 3

	Q1	Q2	Q3	Q4	Q5
Q 1	1	3	3	0.33	0.2
Q 2	0.33	1	0.33	0.2	0.2
Q 3	0.33	3	1	0.2	0.2
Q 4	3	5	5	1	0.2
Q 5	5	5	5	5	1

II. CONCLUSIONS

Today most of the decisions are to be taken in increasingly complex environments. Most of them require different value systems and the use of experts from different fields. They succeed by using knowledge that is imprecise rather than precise. AHP, which is a transparent technique, is very useful to handle this type of situations where qualitative data is involved in the decision-making. The use of AHP does not involve cumbersome mathematics. AHP involves the principles of decomposition, pair wise comparisons, and priority vector generation and synthesis. An application of AHP to a decision-making problem from engineering education field is described in this paper. AHP methodology for the selection of an 'AHPpair wise comparison questionnaire' is discussed with illustrations. Five types of questionnaires are developed and analyzed with respect to three criteria. More insights about the essential features of a measuring instrument are obtained and the analysis finally leads to the development of a new structure to the measuring instrument.

Table 4: Opinion of Expert 4

	Q1	Q2	Q3	Q4	Q5
Q 1	1	0.2	5	0.143	9
Q 2	5	1	5	0.33	9
Q 3	0.2	0.2	1	0.143	9
Q 4	7	3	7	1	9
Q 5	0.111	0.111	0.111	0.111	1

Table 5: Opinion of Expert 5

	Q1	Q2	Q3	Q4	Q5
Q 1	1	3	3	3	7
Q 2	0.33	1	1	1	7
Q 3	0.33	1	1	1	7
Q 4	0.33	1	1	1	7
Q 5	0.143	0.143	0.143	0.143	1

Table 6: judgmental matrix and the ranks of the questionnaires

	Q1	Q2	Q3	Q4	Q5	Priority Vector
Q 1	1	0.56	3.5	1.40	4.41	0.295
Q 2	1.78	1	2.6	1.07	4.41	0.295
Q 3	0.29	0.39	1	0.39	2.14	0.11
Q 4	0.71	0.93	2.55	1	3.54	0.24
Q 5	0.23	0.23	0.47	0.28	1	0.06

CASE 2 : Evaluation of the Significant Renewable Energy Resources in India

The Washington based world watch institute recognizes India as wind superpower and remains as one of the fastest growing market for wind energy in terms of potential and rate of installation. India is placed fourth after Germany, Denmark and the USA. With the available potential and technical expertise and relative ease in power production wind energy tops all the other forms of renewable energy systems in India Initiatives taken by government agencies and other private sectors have encouraged other renewable energy systems also to move forward which motivated to conduct a technical analysis based on AHP to find the influence of each attributes and not to leave alone the other systems like Biomass and Solar energy just on preexisting judgments. This novel approach revealed as well that wind energy seems to be the most promising renewable Proc. of the National Conference on Recent Trends in Mechanical Engineering, RTME 2013, MET's Institute of Engineering, Bhujbal Knowledge City, Nashik – 422 003, M.S., India energy resource as compared to other systems but it has also thrown some light on the areas that has to be considered for bringing solar and biomass energy in equal competence with wind energy in providing a sustainable, cheap and environmental friendly power to the increasing energy demand of India.

CASE 3 : Model to evaluate individual investment performance of retirement planning policy.

Because individual retirement planning investment policy performance assessment is a problem of multi-criteria decision making, this research will be about to provide a framework of assessable individual retirement planning investment policy performance and the optimal individual retirement planning investment policy by using analytic hierarchy process and technique for order preference by similarity to ideal Solution. The essay achieves the object of performance evaluation through comprehending the priority rank of investment policy's principal criteria and sub-criteria under each principal criterion. In other words, the goal of performance evaluation is to understand what the most careful principal criterion is and what the sequence of sub-criteria under every principal criterion is when investors make retirement planning investment decisions.This study wants to develop an evaluation criterion to select the optimal individual retirement planning investment policy. The Synthesis Value of three individual retirement planning investment policies under six criteria are investment performance (0.413), other risk (0.213), liquidity (0.121), taxation (0.115), individual circumstances (0.099) and macroeconomic factors (0.040). Evidently, investment performance (0.413) and other risk (0.213) are high. The proposed criteria can assess the investment policy selection. The Synthesis Values of each of the three individual retirement planning investment policies, are also called the relative weights by taking some three individual retirement planning investment policies as research objects and discuss about the individual retirement planning investment policy performance evaluation, individual retirement planning investment policy of mutual fund, individual retirement planning investment policy of bond, and individual retirement planning investment policy of stocks are considered, in which the wrap enters constructs under the construction evaluation pattern. By applying AHP in obtaining criteria weight and TOPSIS in ranking. Priorities of the three individual retirement planning investment policies are individual retirement planning investment policy of mutual fund, individual retirement planning investment policy of stocks and individual retirement planning investment policy of bond. For this individual retirement planning investment policy performance evaluation in the case implementation, the three individual retirement planning investment policies considered were taken to construct under the evaluation method. The proved evaluation method can select the optimal individual retirement planning investment policy for individual investors and retirees in finding the best performance of a selected individual retirement planning investment policy.

Analytic Hierarchy Process and Expert Choice:

Benefits and Limitations Alessio Ishizaka and Ashraf Labib University of Portsmouth, Portsmouth Business School, Richmond Building, Portland Street, Portsmouth PO1 3DE, United Kingdom The assumption of criteria independence (no correlation) may be sometimes a limitation of AHP (and other MCDM methods). The Analytic Network Process (ANP), a generalisation of AHP with feed-backs to adjust weights, may be a solution. However the decision-maker must answer a much larger number of questions, which may be quite complex: e.g. ¯Given an alternative and a criterion, which of the two alternatives influences the given criterion more and how much more than another alternative. (Saaty and Takizawa 1986). A simplified ANP, while still keeping its proprieties, would be beneficial for a wider adoption of the method. Another direction of the research will probably be on a more soft side. The choice of a hierarchy and a judgement scale is important and difficult. Problem structuring methods could help in the construction of AHP hierarchies.

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