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Implementation of DMAIC Methodology of Six Sigma in Vocational Education and Training for Quality Improvement

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ABSTRACT

DMAIC methodology of Six Sigma is a quality improvement and problem solving technique for an organisation. Majorly manufacturing and production industries implement this technique for betterment of the process. The study in this paper is based on implementing DMAIC technique of Six Sigma in vocational education and training for improving the quality of vocational education while considering the student's perspective. Variety of quality control tools are used in this study to identify the factors affecting the quality education and to solve the issues for the same. During study some key factors like unsatisfactory internship during industrial semester, less time devoted to the practical and lack of interpersonal skills among students are identified. The solutions for the same are found out in a systematic way by using quality control tools (Pareto chart, check sheets, Fish bone diagram). After implementing these solutions for respective issues the Sigma level increased so the overall percentage of satisfied students also increased by 20% for three vital variables. Though still there is a scope of improvement in the mentioned issues but this study will help academician to understand the quality concept in vocational educational and training.

Keywords: *Quality control; Quality improvement; Vocational education and training; Six-Sigma.*

1.0 Introduction

Education system plays a vital role in nation building. The education system could decide the present and predict the future of any country. Since the world is changing and the globalisation is increasing, therefore the education system has also been reformed in many ways. And the new NEP (National Education Policy) 2020 is a recent proof of the education system reforms in India, where VET (Vocational Education and training) has got a special attention. Many business sectors are landing in India for the economic growth of the nation. And these businesses require a huge number of skilled workforce to thrive. The requirement of skilled workforce could be full filled by vocational education institutes. Many developed countries have implemented vocational education in their education system long time before, which could be a reason of their economic growth. Although vocational education has been a part of Indian education system. But the quality of VET need to be improved if it is compared to the other developed countries like Germany, Japan, Korea etc. Students select the VET with an aim of getting certificate, diploma and degree in skills which could make them employable. And their reviews could help in improving the quality of vocational education and training. The quality of vocational education and training could be improved by many methods but the very modern and effective mode could be the Six Sigma. Six Sigma is an approach of quality improvement in order to ensure customer satisfaction. Although Six Sigma is mostly used by manufacturing industries and management professionals but it may be implemented in VET. Implementing the six sigma helps in minimizing defects and deviation thus improve the performance of the system.

DMAIC (Define, Measure, Analyse, Improve, Control) is a data driven technique of Six Sigma to improve the process while finding the defects and eliminating them. An attempt of using DMAIC approach of Six Sigma technique has been made in this paper in the direction of improving existing

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vocational educational and training in one of the department of skill university in the state of Rajasthan.

1.1 Objective

1. To implement DMAIC technique of Six Sigma management tool in the field of vocational education and training.
2. Attempt to find out the issues which could majorly affect the quality of vocational education and training.
3. Figuring out the possible solutions to improve the quality with the help of quality management tools.

2.0 Literature Review

This study gives an idea of the Six Sigma technique and its use in project management. This paper tries to analyse the key factors favourable for six sigma projects. It helps to select effective management and strategies for a six sigma project. It studies the structure of organization used and the contribution of members in achieving the goal of Six Sigma projects. It also reviews the methods used to manage Six Sigma projects for improving the process and to develop a new project. It goes through the techniques applied for examining the project success [1].

Implementation of quality in vocational education and training has been considered in many ways depending upon the culture, education and as per social values of the countries. This paper presents the meaning of quality and the main ideas correlated with its application and assurance. Additionally, the research is aimed towards determining the concept of quality in VET [2].

A case study has been done to brief about the principles of total quality management involved in improving the quality of academic institutes. It gives a broader view to cover whole education institute, rather than educational modules and sections. Strengths and weakness of an institution will be identified by comparing its efforts with total quality management approach. Data from all possible resources is utilised to reach the objectives of the study. The tools highlighted in this study can be implemented in educational institutes for better quality of education [3].

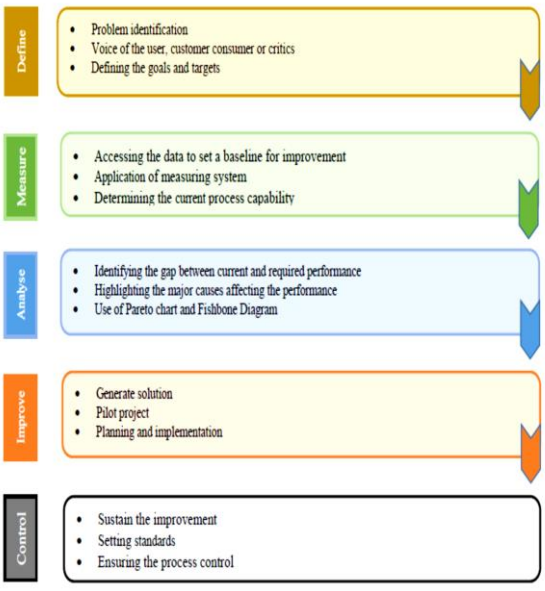
Quality of education may be improved if the DMAIC approach is implemented in institutes. India has not been able to succeed in providing quality education. Six Sigma technique of quality improvement could help in achieving the quality of higher education while reducing non value added activities and improving operational efficiency. There are merely a few studies on the quality of education in India using Six Sigma.

This research paper could help the policy planner of education sector to improve the quality of higher education while considering student's feedback [4]. The study in this research is based on, to implement quality management techniques for desired quality in the production projects [5].

3.0 Methodology

Since the study is based on the improvement in quality of vocational education and training from the student's perception, so a survey is done by a questionnaire which contains a series of questions. Google form is used as a questionnaire for the survey. The responses of the students from the survey are reviewed and analysed. The Sigma level of each question is calculated using DPM (Defect per million) methodology. The sigma level reveals the scope of improvement in a particular section. Once the sigma level is calculated the DMAIC technique of Six Sigma is applied to resolve the issues.

Figure 1: DMAIC Methodology Flow Chart



4.0 Data Analysis and Calculation

All steps of DMAIC methodology are used for data analysis and calculations.

4.1 Define

In this stage the student's point of view is identified for the quality of vocational education and training. For that a survey is done at a skill development university in Jaipur, Rajasthan which runs vocational degree courses. The survey is carried out for the students of B. Voc. (Winter semester 2020-2021). program in manufacturing department. The department had 80 students in three semesters (2^{nd}, 4^{th} and 6^{th}), out of which 55 students have responded in the survey. Semester wise number of students who participated are presented in Table 1.

Table 1: Number of Students Participated in Survey

Semester	Number of students
2^{nd} Semester	22
4^{th} Semester	23
6^{th} Semester	10
Total	55

The mode of survey is a questionnaire. The google form is used as a questionnaire for quick response and for ease of survey. The questionnaire contains 12 questions which are distinct and cover approximately all aspects of vocational education. Every question has rating system from 1 to 5. And the interpretation is as below:

1 = Very Bad,
2 = Bad,
3 = Average,
4 = Good,
5 = Very Good.

The questions are defined as below in the table 2.

The students rated all the questions (Variables). Here dissatisfaction of the students is considered as a defect. Those who rated 4(Good) and 5 (V. Good) are considered satisfied with the ongoing system. The percentage of the student's response as Good and Very Good for each question is fetched semester wise in the table 3 and this data is used to calculate DPM for Sigma level identification.

Table 2: Contains the Description of Variables for Survey

Question No.	Variable	Explanation
1	A_1	Training structure in the department of Manufacturing Skills
2	A_2	Training methodology
3	A_3	Relevancy of study material with practical module
4	A_4	Sufficient time for practical
5	A_5	Machine, equipment and infrastructure
6	A_6	Availability of trainers
7	A_7	Practical assessment process
8	A_8	Personality development and soft skill program
9	A_9	Occupational safety
10	A_{10}	Trainer's knowledge and proficiency
11	A_{11}	Trainer's communication
12	A_{12}	Quality of internship and placements

Table 3: Contains the Percentage of Students who Rated 4 (Good) or 5 (Very Good)

Variable	2^{nd} Semester	4^{th} Semester	6^{th} Semester	Overall
A_1	95	100	100	98
A_2	91	100	100	97
A_3	100	91	90	94
A_4	82	70	40	64
A_5	91	100	100	97
A_6	100	100	40	80
A_7	95	96	100	97
A_8	73	82	40	65
A_9	86	100	100	95
A_{10}	100	100	90	97
A_{11}	100	96	90	95
A_{12}	55	39	10	35

4.2 Measure

The problem/process/issue is evaluated in this stage of DMAIC. There are many ways to evaluate the problem in quality management. Here in this case the sigma level of each question is calculated with the help of DPM calculation.

The DPM calculation process is presented as-

$$\text{Defects per million (DPM)} \frac{\text{Defects X 1000000}}{\text{Sample Size}}$$

Here: Defects = Unsatisfied students who rated 1, 2 or 3

Sample size = 22, 23, 10 (2^{nd}, 4^{th}, 6^{th} Semester Respectively), The interpretation of quality rating is stated in the table 4.

Table 4: Interpretation of Quality Rating

Scale of Quality Rating	Range of Quality Rating	Description of the quality rating
6	Above 5 and up to 6	World-class training and learning facilities
5	Above 4 and up to 5	One of the best training and learning facilities.
4	Above 3 and up to 4	Training and learning facilities is adequate with medium necessary improvements need to be done to set the benchmark of the programme and also gain complete satisfaction from the students.
3	Above 2 and up to 3	Training and learning facilities provided in the programme are acceptable and are just enough to achieve the objective.
2	Above 1 and up to 2	Highly compromised training and learning facilities that have the possibility to hinder the performance of the students.
1	Less than or equal to 1	Completely inappropriate for the students to learn and gain knowledge through the existing academic atmosphere.

Source: Kuwaiti and Subbarayaul, 2015

The defects per million are calculated by using the DPM formula and the respective sigma level for DPM is identified with the help of Sigma table. Sigma level for each variable is given in the table 5.

Table 5: Sigma Level of All Twelve Variables for Corresponding DPM

Variables	Sigma level of all variables
A_1	3.6
A_2	3.3
A_3	3.2
A_4	2
A_5	3.3
A_6	3
A_7	3.3
A_8	2.2
A_9	3.2
A_{10}	3.6
A_{11}	3.3
A_{12}	1.3

- It is observed with reference to the table 4 that the Sigma level of the variables A_1, A_2, A_3, A_5, A_7, A_9, A_{10} and A_{11} lies between 3 and 4. So these variables could be considered as adequate with medium necessary improvements need to be done.
- The Sigma level of variable A_6 is 3 and with reference to the table 4 it acceptable and just enough to achieve the objective.
- But the Sigma level of the variables A_4, A_8 lies between 2 and 3 which indicates the training is highly compromised and the variable A_{12} lies between 1 and 2 which indicates the level of training for that particular variable is completely inappropriate.

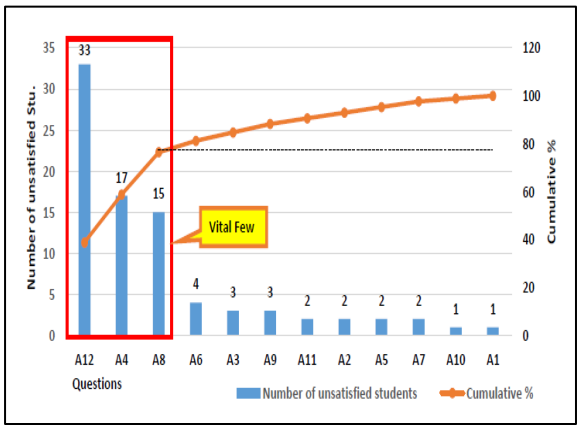
4.3 Analysis

In this stage the measured data is examined and the major factors affecting the quality are highlighted and their weightage for the whole process is identified. Once the vital factors affecting the system are identified, root causes for the same are found out.

Table 6: Number and Percentage of Unsatisfied Students for Specific Variable

Questions	Number of unsatisfied students	Cumulative Number	Cumulative %
Quality of internship and placement.	33	33	39
Sufficient time for practical.	17	50	59
Personality development and soft skills programs	15	65	76
Availability of trainer	4	69	81
Study material relevant to practical.	3	72	85
Occupational safety	3	75	88
Trainer's communication	2	77	91
Training method	2	79	93
Machines and infrastructure	2	81	95
Practical assessment process.	2	83	98
Trainer's knowledge and proficiency	1	84	99
Training structure in school of manufacturing skills.	1	85	100

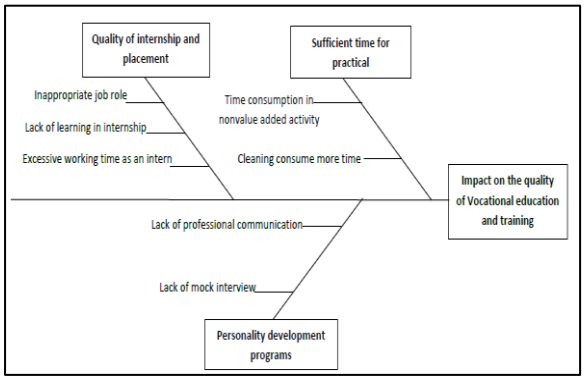
Figure 2: Pareto Chart



Brainstorming and the quality improving tools like Patero Chart & Fish Bone diagram are used to highlight the major issues and to find out the root cause of the problem. Here in this case number and percentage of unsatisfied students for specific variable are listed in the table 6.

After Pareto analysis it is observed that appro.80 percent issues are due to the variables A_4, A_8 and A_{12}. Though rest of the variables also need to be considered for total quality management but their contribution to affect the overall quality is comparatively less. So the cause and effect diagram (figure 3) of the aroused problem is made to find out the possible root causes.

Figure 3: Cause and Effect Diagram (Fishbone Diagram / Ishikawa Diagram)



Further brainstorming is done to reach the root cause of the problem. The brainstorming is done among the VET professionals and the students. Every idea and view is welcomed during brainstorming. The most common and vital causes are selected to work on. Possible causes affecting the quality of vocational education are stated in the cause and effect diagram figure 3.

4.4 Improve

The possible causes derived from analysis are eliminated with possible solutions listed in table 7.

Table 7: Solutions for the Possible Causes Affecting the Quality of VET

Variable	Cause	Solution
A_4	Time consumption in non-value added activity Machine cleaning consumes more time	Time consumption in activities like raw material transmission, tool allotment, excessive theory classes is eliminated. The cleaning of machines on daily basis does not consume more than 10 minutes. Only critical elements like slide ways or any rust sensitive element are cleaned on daily basis. Deep cleaning and routine maintenance of 30 minutes is done once in a week guided by the manual of machine manufacturer.
A_8	Lack of professional communication Lack of mock interviews	Professional communication skills classes are included effectively in the general study. To build the confidence in final year student, mock interviews are conducted in the general education.
A_{12}	Inappropriate job role Lack of learning in internship Excessive working time as an intern	The assigned job responsibility is decided before internship with the approval of institute. Industrial supervisors assign technical and professional tasks to the students for better learning. Labour tasks are assigned as less as possible. Collaboration with the industries is initiated which consider employee welfare as one of its priority, so that the students don't suffer industrial semester due to work overload.

Further this include brain storming. The solutions are accepted by the higher authority and implemented in the summer semester 2020-2021. The outcomes due to adjustments or modification are further reviewed and discussed in the result section.

4.5 Results

After implementing the suggested solutions, the quality improvement process with DMAIC technique is repeated for the ongoing session. As per II survey, the results are listed in the table 8.

Table 8: Sigma Level after Implementing Solution for New Session of 79 Students

Variable	A_4	A_8	A_{12}	Average
Number of unsatisfied students	11	9	24	-
Sigma level From I survey	2	2.2	1.3	1.8
Sigma level from II survey	2.6	2.8	2.1	2.5

Improvements in the concerned variables are witnessed in the form of increased Sigma level. The number of unsatisfied students decrease as compared to the previous survey, which is a motivating response for further improvement. The percentage of students who rate good and very good in the new survey for critical variables is calculated in table 9.

$$\text{Percentage of satisfied students} = \frac{\text{Number of satisfied students} * 100}{\text{Total number of students}}$$

It is seen that quality of training has been improved as more number of students are satisfied with the new system. The percentage of satisfied students increases 17% for variable A_4, 15% for variable A_8 and 29% for variable A_{12}. The overall increased percentage is approx. 20% in the quality of the training. Moreover, still there is scope of improvement in the VET.

Table 9: Percentage of Satisfied Students in the First and Second Survey

Variable	A_4	A_8	A_{12}	Average
From first survey	69	73	40	60.67
From second survey	86	88	69	81

4.6 Control

Eventually in this stage of DMAIC technique, the implementation of the solutions is ensured throughout the improved process and the reviews for the ongoing system are recorded in the form of data which are further tracked for the betterment in the system. Regarding this study, following measures are adopted to ensure the continuous improvement in terms of student's satisfaction in VET.

Table 10: Control Check Sheet

Sr. No.	Particulars	Countermeasures
1	Student's perspective for training	Periodic feedback at the end of each training module
2	Student's development and learning in industry	Allotment of mentors as an associate of university and to monitor student's learning in industry
3	Expectations of industry	Brainstorming by training and placement department and inclusion of additive skills and knowledge in course curriculum required by industry.
4	Student's Communication	Technical English speaking practice is made compulsory during academic session

5.0 Conclusions

The purpose of this research was to improve the quality of vocational education and training with the help of DMAIC techniques by figuring out the key factors affecting the quality. The quality control tools help to figure out the problems and to find the possible solutions. It is found that 80% issues in vocational education and training (VET) are occurring due to the variables, A_4, A_8 and A_{12}. Followed by Pareto analysis the solutions are implemented to solve the issues. These issues are solved at some extent and it is found that sigma level and the percentage of satisfied students got increased for key variables. The overall increased sigma level for three key variables is from 1.83 to 2.5 and the overall increase in the percentage of satisfied students for the same variables is witnessed from 61% to 81% (20%). Since the quality improvement is a never ending phenomenon so a control check sheet is prepared to standardise the process for continuous improvement. This study can facilitate the policymakers and academicians while approaching DMAIC technique to improve the quality of vocational education and training.

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