# Failure Mode and Effect Analysis: A Tool to Enhance Quality in Engineering Education

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**Abstract**

It is very important to change or make improvement in engineering education, How long an institute or university can survive? If it is just passing the students for B.E certificates and not able to improve students quality. Improving and sustaining quality in technical education is a growing concern among stakeholders of the system. The quality journey which focuses on continuous improvement of processes, products and services through well planned and efficient management of technical education.

In this paper an attempt has been made to assess the reasons behind the failures in some subjects of the mechanical engineering course. Failure Mode and Effect Analysis (FMEA) is a tool used to detect the reasons and finally the recommendations were made to solve the problems occurred in the course.

**Key words**: FMEA, Occurrence, Detection, Severity, Risk Priority Number, Quality

## 1. INTRODUCTION

Continually measuring the reliability of a machine, product or process is an essential part of Total Quality Management. When acquiring new machines, creating a new product or even modifying an existing product, it is always necessary to determine reliability of the product or process. Then what is Reliability? The reliability may be defined as the probability of the product to perform as expected for a certain period of time, under the given operating conditions and at a given set of product performance characteristics. Reliability is also an important aspect when dealing with customer satisfaction. Whether the customer is internal or external. The reliability is not only applicable to production but also to service.

Failure Mode and Effect Analysis (FMEA) is an *analytical technique* that combines the technology and experience of people in identifying foreseeable failure modes of a process and planning for its elimination. In other words FMEA can be explained as a group of activities intended to "*Recognize and evaluate the potential failure of a product or process and its effects. Identify actions that could eliminate or reduce the chance of potential failures [1] "*

FMEA attempts to detect the potential product/process related failure modes. The technique is used to anticipate causes of failure and prevent them from happening. FMEA uses Occurrence of failure and Detection probability

criteria in conjunction with Severity criteria to develop Risk Prioritization Number for the prioritization of corrective action considerations.

## 2. TERMINOLOGY

The following terms are used in the FMEA.

**2.1. Potential failure mode**: It may be one of two things; first it may be the method in which the item being analyzed may fail to meet the design criteria. Second, it may be method that may cause potential failure in higher- level system or may be the result of failure of lower-level system.

**2.2. Severity(S):** It is the assessment of the seriousness of the effect of potential failure mode to the next system or customers if it occurs. It is important to realize that the severity applies only to the effect of the failure, not the potential failure mode. Reduction in severity ranking must not come from any reasoning except for a direct change in design of the system.

The severity be rated on 1 to 4 scale with a 1 being no harm, 2 being minor harm, 3 being low harm and 4 being high harm

**2.3. Occurrence (O):** It is the chance that one of the specific cause/mechanism leads to failure. The reduction or removal on occurrence ranking must not come from any reasoning except for a direct change in the design.

Like severity criteria the likely hood of occurrence of failure is based on 1 to 4 scale with a 1 being not at all, 2 being rare occurrence,3 being some times and 4 being always occurrence.

**2.4. Detection (D):** It is the relative measure of the assessment of the ability of the design control to detect a potential cause/ mechanism or the subsequent failure mode during the system operation.

Like other two criteria the detection also based on 1 to 4 scale with a 1 being highly detectable , 2 being very easy to

Detect, 3 being moderately detectable and 4 being uncertain detection

**2.5. Risk Priority Number (RPN):** It is the product of Severity(S), Occurrence (O) and Detection (D)

**RPN = S*O*D**

The product may be viewed as a relative measure of the risk. Here values for RPN can range from 1 to 64 with 1 being smallest risk and 64 is the highest risk. For parameters with highest RPN make efforts to take corrective action to reduce RPN [2]. The purpose of the RPN is to rank the various parameters; concern should be given for every method available to reduce the RPN.

## 3. CASE STUDY:

We have seen more number of failures in some subjects of Mechanical Engineering course, A research has been taken up to know the reasons for the same from students, faculties and the subject experts with different sets of questionnaire to make one cycle.

The survey has been conducted in the Department of Mechanical Engineering, Sambhram Institute of Technology, Bangalore, the responses were collected apprehensively by students, faculty and subject expert on questionnaires comprising different criteria's . About 54 students of VI Semester were asked to give response to the subject "MECHANICAL VIBRATION" with the given questionnaire. The questionnaire comprises the questions regarding the fear about the subject/faculty, individual care, syllabus coverage, opportunity for creativity, usefulness of notes for exams, cleanliness of classrooms, availability of good books in the library, input quality of the student, poor in basic science fundamentals, valuators competency, variation in the scheme of the valuation among the valuators, present examination system. The questions were close ended type with options **Always/ some times/ rarely/ not at all.** The respondents were asked to select any one appropriate answer from the given options.

The following Table1 shows the responses from the students in the subject called Mechanical Vibrations.

**Table 1. Analysis of student's responses**:

| SL. No. | DETAILS | Subject: Mechanical Vibrations | | | | |
|---|---|---|---|---|---|---|
| | | Occurrence (O) | Severity (S) | Detection (D) | (RPN) | Ranking |
| 1 | Fear about the subject & fear about the faculty | 3.34 | 3.43 | 2.0 | 23.53 | **V** |
| 2 | Contextualization of the subject with practical application | 3.0 | 3.0 | 3.0 | 27.00 | **IV** |
| 3 | Individual care of students | 4.43 | 4.43 | 3.0 | 58.87 | **I** |
| 4 | Syllabus coverage | 2.33 | 2.33 | 1.0 | 5.43 | **X** |
| 5 | Opportunities for self learning, confidence building and creative thinking | 3.22 | 3.22 | 3.22 | 33.39 | **III** |
| 6 | Student's problems solving | 2.33 | 2.33 | 2.33 | 12.65 | **VII** |
| 7 | Usefulness of notes to the examination | 3.43 | 3.43 | 3.43 | 40.35 | **II** |
| 8 | Concurrency of lectures with pattern of question paper | 3.43 | 3.43 | 1.0 | 11.76 | **IX** |
| 9 | Availability of text books and reference books | 4.0 | 4.0 | 1.0 | 16.00 | **VI** |
| 10 | Cleanliness of classrooms | 3.44 | 3.44 | 1.0 | 11.84 | **VIII** |

**3.1. Findings:**

**3.1.1.** It is seen that the serial number 3 carries highest RPN, where students expressed that they have not given the individual care and attention.

**3.1.2.** The notes issued by the faculty are not useful for the examination purpose.

**3.1.3** The self confidence building and encouragement for creative thinking is very less.

**3.1.4** There is no contextualization of the subject and topics with practical applications.

**3.1.5** The students have inbuilt fear about the subject

**3.1.6** There is no availability of good text books in the library.

**3.1.7** The Faculty is unable to solve the problems raised by the students

**3.1.8** The class rooms are not clean for the sessions.

**3.1.9** The class lecture is not in line with the question paper pattern.

**3.1.10** There is no cent percent syllabus coverage.

**3.2. Recommendations:**

**3.2.1** The individual care and attention should be given to each student. The proctor scheme can be introduced.

**3.2.2** The faculty is informed to provide good notes to the students.

**3.2.3** The students are given chance for development of creativity, by conducting seminars, debates, group discussions and mini projects.

**3.2.4**The faculty members are advised to correlate their subject with the practical applications.

**3.2.5** The students are motivated and encouraged to remove the inherent fear about the subject.

**3.2.6** Good text books and reference books are recommended to the library.

**3.2.7** Faculty should be informed to be prepared to face the questions.

**3.2.8** House keeping department is informed to keep clean the class rooms before the session starts.

**3.2.9** Faculty informed to solve the previous year question papers after each chapter completion.

**3.2.10** The faculty is monitored to cover the cent percent syllabus.

The following Table 2. Shows the responses from the faculty of the subject called Mechanical Vibrations.

**Table 2. Analysis of faculty response:**

| SL. No. | DETAILS | Subject: Mechanical Vibrations | | | | |
|---|---|---|---|---|---|---|
| | | Occurrence (O) | Severity (S) | Detection (D) | (RPN) | Ranking |
| 1 | choice of the subject | 1.0 | 1.0 | 1.0 | 1.0 | **VI** |
| 2 | input quality of the student to the course | 3.0 | 3.0 | 1.0 | 9.0 | **V** |
| 3 | some topics are above the understanding level of students | 3.0 | 3.0 | 3.0 | 27.0 | **III** |
| 4 | students are poor in basic science fundamentals | 3.0 | 3.0 | 3.0 | 27.0 | **III** |
| 5 | Syllabus coverage | 3.0 | 3.0 | 1.0 | 9.0 | **V** |
| 6 | Availability of text books and reference books | 3.0 | 3.0 | 1.0 | 9.0 | **V** |
| 7 | Fear about the subject | 4.0 | 4.0 | 4.0 | 64.0 | **I** |
| 8 | students read for the exam purpose only and not for knowledge | 4.0 | 4.0 | 3.0 | 48.0 | **II** |
| 9 | class room compatibility | 4.0 | 4.0 | 1.0 | 16.0 | **IV** |
| 10 | pattern of question paper on performance | 4.0 | 4.0 | 3.0 | 48.0 | **II** |

**3.3. Findings:**

3.3.1. It is seen that the serial number 7 carries highest RPN; Students have inherent fear about the subject

3.3.2. a) Students read only for exam purpose not knowledge.

3.3.2. b) The question paper pattern matters on the performance

3.3.3. Students are poor in basic science fundamentals.

3.3.4. Class rooms are not compatible for teaching

3.3.5. a) There no availability of good text books in the library.

3.3.5. b) The in put quality of the students is low to the course.

3.3.6. There is no choice of the subject on there wishes

**3.4. Recommendations:**

3.4.1. The students are motivated and encouraged to gain confidence over the subject.

3.4.2. a) The students are encouraged for knowledge oriented study.

3.4.2. b) Students are given sufficient number of tests with wide variety of questions to get ready to face the final exam.

3.4.3. Students are given a bridge course to learn basic science fundamentals.

3.4.4. House keeping department is informed to keep the class rooms clean before the session starts. The concerned authority is informed to equip the rooms with essential infrastructure.

3.4.5. a) Good text books and reference books are recommended to the library.

3.4.5. b) All admitted students are made to undergo special training programs to improve their knowledge.

3.4.6. The subject allotment should be made on the choice of the faculty.

The following Table 2. Shows the responses from the subject expert of the subject called Mechanical Vibrations

**TABLE 3. Analysis of Subject expert's response**:

| SL. No. | DETAILS | Subject: Mechanical Vibrations | | | | |
|---|---|---|---|---|---|---|
| | | Occurrence (O) | Severity (S) | Detection (D) | (RPN) | Ranking |
| 1 | Relevance of some topics in the subject | 1.0 | 1.0 | 1.0 | 1.0 | **VI** |
| 2 | Communication gap between faculty and subject experts | 3.0 | 3.0 | 1.0 | 9.0 | **III** |
| 3 | High standard Syllabus | 1.0 | 1.0 | 3.0 | 3.0 | **V** |
| 4 | input quality of the student to the course | 3.0 | 3.0 | 3.0 | 27.0 | **I** |
| 5 | Deviation from guidelines in paper setting | 3.0 | 3.0 | 1.0 | 9.0 | **III** |
| 6 | Valuators competency | 2.0 | 2.0 | 1.0 | 4.0 | **IV** |
| 7 | Scheme variation among valuators | 2.0 | 2.0 | 4.0 | 16.0 | **II** |
| 8 | Marks variation among valuators | 3.0 | 3.0 | 3.0 | 27.0 | **I** |
| 9 | Action against non serious valuators | 3.0 | 3.0 | 1.0 | 9.0 | **III** |
| 10 | Wheat her the Present examination is the best? | 1.0 | 1.0 | 3.0 | 3.0 | **V** |

**3.5. Findings:**

1. It is seen that the serial number 4 & 8 carries highest RPN; a) Input quality of the student to the course it self is low b) It is found that there is marks variation among the valuators.
2. There is a variation in the valuation scheme among valuators.
3. a) The paper setters deviate from guidelines while paper setting
   b) There is no action against non-serious valuators.

c) There communication gap between the paper setter and the faculties engaging the subject.
4. The valuators may not be engaging the subject but they go for valuation.
5. Some topics are above the understanding level of the students.

**3.6. Recommendations:**

1. a) All admitted students are made to undergo special training programs to improve their knowledge.
   b) The moderator of the valuation should observe the extreme variation and take necessary action.
2. The valuators are informed to adhere to the valuation scheme.
3. a) The paper setters are given with the guidelines while preparing the question papers
   b) Examination authority is asked to take actions against the non-serious valuators.
   c) The communication should be encouraged between the paper setter and the faculties engaging the subject
4. The strict observation should be made by the college authority to send the faculties to the valuation only who deal with the subject.
5. The syllabus framing committee should observe topic relevance and understanding level of the student.

## 4. CONCLUSION

The application of the tool Failure Mode and Effect Analysis (FMEA) in the technical education yields better results. The highest RPN number is given highest priority to solve the problems. The recommendations for the system will reduce the risk of failures in the system. By the proper understanding and application of Total Quality Management tools leads to the better quality in the education system.

## 4. REFERENCES:

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