Abstract- This research paper aims to improving engineering training quality in Moroccan schools. It focuses on the learning assessment component that enables to evaluate the acquisition of the learned notions by the Moroccan engineering students.

To achieve the purpose of this study, we analyzed the assessment in a Moroccan engineering school, and we established the process of evaluation. We then used the FMEA (Failure Modes and Effects Analysis) method to consider the process and suggest solutions that enables its improvement. We then recommended a monitoring plan, which enables the monitoring and control of the studied assessment process various steps.

This present research aims at improving the engineering program quality and to give teachers and decision-makers the means to monitor the improvements made, particularly the students learning assessment. This work will also help to improve the accreditation of engineering schools to enable Moroccan diplomas to meet the international standards.

Keywords: quality, engineering, assessment, FMEA, learning outcomes.

I. INTRODUCTION

In a world in continuous changes, the competitiveness of nations is measured by the quality of human capital. This explains the major role of education systems, which are the basis of the process of training and qualification of human resources [1]. Indeed, performance has become ubiquitous in all spheres of human activity, including training, more particularly the training of engineers.

Facing globalization, institutional inconsistencies and knowledge uncertainties make decision-making more and more difficult. The role of the engineer is to act and generate changes facing this complexity [2]. In addition, the engineers training are becoming essential in meeting the economic and social challenges that arise from the digital revolution [3]. It is in this perspective that higher education in Morocco, in particular the training of engineers, has evolved during the last decade. Indeed, it has experienced a great expansion in the disciplines taught and a notable improvement in the training quality.

In recent years, several countries have adopted the quality approach in improving education to ensure the quality of learning in education and training institutions. Moreover, one of the elements necessary for the quality of the "educational act" is the evaluation of learning processes and results [4].

In his study on the evolution of higher education in Morocco since independence, Zouaouui states that the absence of tutoring and evaluation are some of the important factors that lead to the degradation of the quality of Moroccan education [5].

According to [6], assessment is a mandatory step in any training system because it can provide the value of the level of acquisition of skills and knowledge of learners. The role of assessment is to allow the learner to position himself regarding the concepts and skills covered. For the educator, the role of evaluation is twofold depending on
whether he is interested in the evaluation of learning or the evaluation of the training system. Assessment is a process that must be consistent with the objectives pursued as well as with the method and tools used. We have to know what to assess and how to assess it before starting teaching [7].

The starting point of this research was a study of the assessment process in a Moroccan engineering school. This study allowed us to define the process and the different steps of assessment. Then we used the FMEA method to analyze it and suggest a monitoring plan.

II. RESEARCH QUESTIONS AND METHODOLOGY

The goal of this research paper is to examine the following research questions:

• What is the assessment process used in Moroccan engineering schools?

• What are the actions that can help to improve the assessment process and how to monitor this improvement?

The study is based on a pragmatic inductive approach. We adapted and adopted the quality tools used in industry and services to study and improve the learning assessment process.

III. FMEA ANALYSIS

In order to ensure quality maintenance, several steps are necessary. We must start by confirming and describing the current situation. We should validate the standards, set up the processes and identify, break down and understand the known non-conformities. Then, we should highlight the process elements related to the parameters of the quality. Third, it is necessary to define the conditions of non-quality and to establish an action plan to improve them. Finally, it is necessary to monitor the results and revise the standards in case of detection of non-conformity [8].

The FMEA analysis method applies equally to the design of a new product, to the development of a manufacturing process or a process to identify the probable failures that could affect the performance [9].

An inductive method makes it possible to highlight critical points and proposals for corrective or preventive solutions. There are six stages to implementing FMEA:

• The definition of the study limits;

• Identification of the elements to be studied (environment and process subsets);

• Identification of failure modes;

• Identification of the effects of the failure modes;

• Identification of failures causes;

• Implementation of the monitoring plan.

The FMEA study on the assessment process in a Moroccan engineering school is exposed below.

III.1. DEFINITION OF THE STUDY LIMITS

In our study, the objective of the FMEA analysis is to let the assessment reflect the effective level of the engineering students. Therefore, the system to study corresponds to the evaluation process used in the Moroccan engineering schools. The
The functional analysis of the assessment process allows us to highlight three main functions, which are:

- Preparation of the assessment;
- Assessment (review);
- Correction.

III.2. IDENTIFICATION OF THE ELEMENTS TO STUDY

The environment for the assessment process consists of courses, practical work, tutorials, internships, projects, presentations...

We can divide the evaluation process into three subsets:

- Preparation of the assessment, which must be in line with the objectives and the learning outcomes targeted;
- Assessment methods, which must be relevant, consistent and efficient;
- Correction, which must be fair and reliable.

The figure below shows these subsets.

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**Fig. 1.** Assessment process in a Moroccan Engineering school.

**Fig. 2.** Subsets of the assessment process.
The figure (Fig. 2.) above describes the subsets of the evaluation process and the characteristics required for each subset.

III.3. IDENTIFICATION OF FAILURE MODES

The failure mode is the observable form of the malfunction of a product or an operation of the studied system. We defined failure modes for each subset of the assessment process.

• Preparation of the assessment

In this step, two criteria are necessary: the adequacy of the assessment with the objectives and the adequacy of the assessment with the learning outcomes. The failure modes of these two criteria are:

- No function: the adequacy is not achieved or has ceased to be achieved;
- Degraded function: the adequacy is not achieved perfectly (performance deterioration).

• Assessment methods

In this step, three criteria are necessary: the pertinence of the evaluation methods, their consistency and their efficiency. The failure modes of these three criteria are:

- No function: the pertinence, the consistency and the efficiency are not achieved or have ceased to be achieved;
- Degraded function: the pertinence, the consistency and the efficiency are not achieved perfectly (performance deterioration).

• Correction

In this step, two criteria are necessary: the equity and the reliability of the assessment. The failure modes of these two criteria are:

- No function: the equity and the reliability are not achieved or have ceased to be achieved;
- Degraded function: the equity and the reliability are not achieved perfectly (performance deterioration).

III.4. IDENTIFICATION OF THE EFFECTS OF THE FAILURE MODE

The various failure modes and causes mentioned above can have three potential effects as follows:

• Effect on the module: Students validate a module even if they have not acquired the skills and knowledge set for this module. This implies a lacuna, which could harm them in the learning that has as prerequisite the knowledge relating to that module.

• Effect on the diploma: Students validate the year or obtain the diploma with lacunas, which implies a bad reputation of the diploma with employers and industry professionals.

• Effect on equity: Students who make the most effort are disadvantaged compared to those who manage to get exams and therefore have better grades. This problem becomes more important when the conventions and opportunities provided by the school bases on student rankings.

III.5. IDENTIFICATION OF FAILURE CAUSES

We can define the causes as the origin of the potential failure mode. They can be determined by
answering the question: “What are the causes that could generate the potential failure mode?” [10].

There are two types of causes leading to the failure mode: Internal causes and external causes.

Brainstorming with members of the research team as well as an in-depth literature review enabled us to target the causes of the various potential failures identified for the assessment process.

We have gathered the results obtained in the table below.

Table I: Causes of learning outcomes assessment process failure modes.

<table>
<thead>
<tr>
<th>Assessment preparation</th>
<th>Process Subsets</th>
<th>Potential failure mode</th>
<th>Effects of the failure mode (on the)</th>
<th>Possible causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adequacy with objectives</td>
<td>No Function</td>
<td>Module</td>
<td>Course objectives are not defined and / or updated</td>
<td>- The assessment methods are not adapted to the objectives of the course (example: lecture without exercises and exam in the form of exercises) - There is no consistency between teaching methods and assessment instruments</td>
</tr>
<tr>
<td>Adequacy with objectives</td>
<td>Degraded Function</td>
<td>Module and Diploma</td>
<td>The assessment focuses on elements not covered in the course (difficult questions, traps, demonstrations, etc.)</td>
<td>The situation does not validate the learning outcomes targeted by the course</td>
</tr>
<tr>
<td>Consistency</td>
<td>No Function</td>
<td>Module and Diploma</td>
<td>Terminal, intermediate and course-specific learning outcomes are not defined</td>
<td>Student results are not analyzed at the end of each year and are neither discussed nor disseminated</td>
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Assessment methods

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<tr>
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<th>Potential failure mode</th>
<th>Effects of the failure mode (on the)</th>
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</tr>
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<tr>
<td>Pertinence</td>
<td>Module</td>
<td>Degraded Function</td>
<td>The situation is not adapted to the concepts taught</td>
</tr>
<tr>
<td>Module</td>
<td>Module and Diploma</td>
<td>The situation is not carried out in a situation</td>
<td>The assessment asks the students to repeat and reproduce what is said during the course (definitions, equations to learn …), restitution of the course</td>
</tr>
<tr>
<td>Diploma</td>
<td>Module and Diploma</td>
<td>The situation does not reflect what we find in reality</td>
<td>Assessment does not validate the learning outcomes targeted by the course</td>
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Table: Causes of learning outcomes assessment process failure modes.
### III.6. IMPLEMENTATION OF THE MONITORING PLAN

The Monitoring Plan is a summary of all the controls carried out to ensure the smooth running of the process. The IATF 16949 standard considers monitoring plans as an output from the quality plan. It also defines it as a "Documented description of the systems and processes necessary to control the production of the product".

In our study, the monitoring plan illustrates the solutions proposed to avoid the causes of failure modes in the assessment process.

We have proposed a monitoring plan based on three main reference documents, which are the training accreditation procedure, the evaluation...
The accreditation procedure responds to the causes defined in the table below.

Table II: Causes and solutions in relation with accreditation procedure.

<table>
<thead>
<tr>
<th>Possible causes</th>
<th>Control measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course objectives are not defined and / or updated</td>
<td>In the accreditation file: require a clear definition of objectives and an update every X years</td>
</tr>
<tr>
<td>The course objectives are not determined in terms of knowledge and skills to be acquired</td>
<td>Accreditation: define and explain the objectives then detail them in skills and knowledge to acquire</td>
</tr>
<tr>
<td>Terminal, intermediate and course-specific learning outcomes are not defined</td>
<td>Accreditation procedure: set up the required L.Os</td>
</tr>
<tr>
<td>Learning outcomes are defined but are not clarified into knowledge and skills to be acquired</td>
<td>Once the L.Os are defined, break them down into skills and knowledge to be acquired for each course</td>
</tr>
</tbody>
</table>

From the table above, we can conclude that, in order to improve the assessment system in engineering schools, the accreditation procedure should require:

- Define the general and specific objectives for each course;
- Update these objectives systematically over a determined deadline;
- Explain the objectives in terms of knowledge and skills to be acquired by the student;
- Define the terminal, intermediate and specific learning outcomes for each course;
- Decline the learning outcomes in the form of knowledge and skills to acquire by the student.

The evaluation procedure addresses the causes defined in the table below.

Table III: Causes and solutions in relation to assessment procedure.

<table>
<thead>
<tr>
<th>Possible causes</th>
<th>Control measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>The evaluation focuses on elements not covered in the course (difficult questions, traps, demonstrations, etc.)</td>
<td>Link assessment to course objectives in the assessment process</td>
</tr>
<tr>
<td>The evaluation methods are not adapted to the objectives of the course (example: lecture without exercises and exam in the form of exercises) There is no consistency between teaching methods and assessment instruments</td>
<td>Link assessment to course objectives in the assessment process</td>
</tr>
<tr>
<td>The evaluation methods are not adapted to the objectives of the course (lecture without exercises and exam in the form of exercises) There is no consistency between teaching methods and assessment instruments</td>
<td>Link assessment to the learning to be assessed for each course in the assessment procedure</td>
</tr>
<tr>
<td>The assessment does not validate the learning outcomes targeted by the course</td>
<td>Link the assessment methods to the prior learning to be assessed for each course in the assessment procedure</td>
</tr>
<tr>
<td>Issue</td>
<td>Description of the Problem</td>
</tr>
<tr>
<td>-------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>The evaluation operation is not carried out in a &quot;situation&quot;</td>
<td>The evaluation is not focused on results only and does not take into account the resolution process.</td>
</tr>
<tr>
<td>The situation does not reflect what we find in reality</td>
<td>The situation is not adapted to the concepts taught.</td>
</tr>
<tr>
<td>Assessment does not regulate learning activities (assessment, feedback, analysis, rehabilitation)</td>
<td>The situation is not adapted to the student’s level (1st year, 2nd year or 3rd year).</td>
</tr>
<tr>
<td>The evaluation asks the students to repeat and reproduce what is said during the course (definitions, equations to learn ...), restitution of the course</td>
<td>The evaluation criteria are defined but are not common (each defines them in their own way).</td>
</tr>
<tr>
<td>There are no or few oral and continuous checks</td>
<td>Assessments provide superficial exercises that do not require analytical or associative thinking.</td>
</tr>
<tr>
<td>Assessments are too complex and exceed students' goals and abilities</td>
<td>The evaluation is not progressive: formative evaluations, feedback, certification evaluation.</td>
</tr>
<tr>
<td>The evaluation is not transparent: the students are not clearly informed of the evaluation criteria</td>
<td>Assessments are not of increasing difficulty</td>
</tr>
<tr>
<td>The exams are repetitive or already exist on the internet</td>
<td>Feedback on students results is not communicated to them.</td>
</tr>
<tr>
<td>The evaluation is incomprehensible: Incomplete case studies, poorly formulated exercises (errors, incomplete diagrams)</td>
<td>Assessment does not regulate learning activities (assessment, feedback, analysis, rehabilitation).</td>
</tr>
<tr>
<td>Assessments are not of increasing difficulty</td>
<td>The exams are repetitive or already exist on the internet.</td>
</tr>
<tr>
<td>Assessments are not of increasing difficulty</td>
<td>Feedback on students results is not communicated to them.</td>
</tr>
<tr>
<td>There is no scoring grid</td>
<td>The evaluation is not progressive: formative evaluations, feedback, certification evaluation.</td>
</tr>
<tr>
<td>There is no scoring grid</td>
<td>The exams are repetitive or already exist on the internet.</td>
</tr>
<tr>
<td>There is no scoring grid</td>
<td>The evaluation is not transparent: the students are not clearly informed of the evaluation criteria</td>
</tr>
<tr>
<td>Evaluation criteria and indicators are not clearly defined</td>
<td>The exams are repetitive or already exist on the internet.</td>
</tr>
<tr>
<td>The exams are connected from each other, the assessment is not done collegially</td>
<td>The exams are repetitive or already exist on the internet.</td>
</tr>
<tr>
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<td>The exams are repetitive or already exist on the internet.</td>
</tr>
<tr>
<td>A language problem with some students does not allow them to understand the statement of the assessment.</td>
<td>A language problem with some students does not allow them to understand the statement of the assessment.</td>
</tr>
</tbody>
</table>
The table above allows us to conclude that the evaluation procedure must:

- Enable the link between the course objectives and the evaluation;
- Enable the link between the learning outcomes relating to the course and the content of the assessment;
- Enable the link between learning outcomes and assessment methods and instruments;
- Allow the choice of appropriate assessment methods and situations at the student level (neither too easy nor too difficult);
- Require to re-study the exam by a peer before it is adopted for assessment;
- Set up a feedback system to follow by all teachers;
- Set up a system that clearly defines the measurement criteria and indicators of the evaluation, in particular with regard to the rating;
- Re-study every evaluation situation to detect its strengths and weaknesses in order to improve it;
- Regulate learning activities by following the assessment, feedback, analysis, rehabilitation or upgrading process;
- Allow collegial assessment and consultation between the different subject teachers so that the assessment is constructive and that there is a link between the different assessments;
- Set up a formative evaluation system that helps prepare students for certification evaluations;
- Set up an information system for students on the methods, mechanisms and evaluation criteria;
- Set up a method for detecting students’ language gaps and offer language training, internally or externally, to students with the most problems.

The procedure for monitoring the evaluation system makes it possible to respond to the causes defined in the table below.

Table IV: Causes and solutions to the assessment system monitoring procedure.

<table>
<thead>
<tr>
<th>Possible causes</th>
<th>Control measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher education teachers are not trained in assessment, they learn on the job</td>
<td>Set up continuous training sessions in evaluation</td>
</tr>
<tr>
<td>Assessment practices take into account the characteristics of the students and aim to respect certain tacit docimological standards (for example a group average that is neither too low nor too high)</td>
<td>Eliminate as much as possible the constraints on teachers to reduce the effects of docimological standards</td>
</tr>
<tr>
<td>Poor exam conditions: repetition of the same questions from year to year, students having access to the exam questions in advance, fraud during the exam, etc.</td>
<td>Set up a system for monitoring exam conditions to limit unfavorable conditions</td>
</tr>
<tr>
<td>Student results are not analyzed at the end of each year and are neither discussed nor disseminated</td>
<td>Set up a procedure for analyzing and studying student results and integrating it into the evaluation procedure</td>
</tr>
</tbody>
</table>

The table above allows us to conclude that, in order to improve the evaluation system in
engineering schools, the evaluation system monitoring procedure must:

- Set up a continuous training schedule for professors and higher education teachers on evaluation, correction and feedback methods,

- Set up an evaluation monitoring committee to avoid conditions unfavorable to a fair and reliable evaluation,

- Require a procedure for analyzing and studying student results.

- Minimize the constraints of results on professors and higher education teachers to reduce the effect of docimological standards.

III.7. SUMMARY OF THE FMEA

The FMEA analysis allowed to identifying failure modes that can affect the assessment process in engineering schools. It also allowed to identifying the three essential elements to set in order to allow evaluation in engineering schools to meet criteria of adequacy, pertinence, consistency, efficiency, equity and reliability.

The three elements to set up are:

- An evaluation procedure;

- A procedure for monitoring the evaluation system;

- An accreditation procedure, which takes into account the learning outcomes and the course objectives.

IV. CONCLUSION

Whether it is the evaluation of training courses or of teaching, evaluation is a way of paying attention to the quality of the service provided. The current problem of higher education institutions is no longer just to manage the influx of students, but also and above all to focus on the quality of the education offered [11]. Any activity aimed at continuous renewal of the education system must be accompanied by an upstream, downstream and in-Itineris evaluation [12].

It is in this perspective of improving the quality of teaching that we have conducted this study. In our analysis, we opted for a case study on a Moroccan engineering school using the FMEA method. The FMEA analysis of the assessment process allowed us to identify the deficiencies related to the assessment as well as their causes and effects. Then, we proposed a monitoring plan with three procedures as references:

- A procedure relating to accreditation;

- A procedure for monitoring the evaluation system;

- An evaluation procedure.

This study can serve to improve the evaluation process by implementing the procedures recommended and by respecting the control measures for each procedure. The present paper suggests that a future study suggests the procedures according to the monitoring plan, to enable the assessment process to be adequate with the learning outcomes, pertinent, consistent, efficient, equitable and reliable.

References


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