Improvement of the Engineering Student's Training inside University Laboratories through Quality Management Systems

Podestà, L. [1]
Assistant Professor
Department of Astronautics, Electrical and Energetics Engineering, University of Rome "La Sapienza"
Rome, Italy

Sforza, G.
PhD Student
Department of Astronautics, Electrical and Energetics Engineering, University of Rome "La Sapienza"
Rome, Italy

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INTRODUCTION

This article analyzes the potentialities and the various consequences that may occur during engineering student's educational path when they undertake a training activity, both if it is a thesis work or an internship, in a laboratory implementing a Quality Management System (QMS).

This is important because it may change the job's organization (perspectives) and the problem solving approach, and it gives students a very important added value appreciated in workplaces.

It is important to explain some relevant points in order to understand how a Quality Management System (hereafter referred to as QMS) can give a significant support to students' training. For this purpose some topics on which part of the proposed activity is based will be taken from [1] and explained from a different point of view.

1 GENERAL DEFINITIONS AND CONSIDERATIONS

1.1 Open Coordination Method to Plan an Educational System

Definition of an "open coordination method":

1) It is necessary to define the standard qualitative and quantitative indicators between the partners, in order to obtain an homogeneous comparable data set; this is useful for inter-laboratory exchange.
2) It is important to take into account the planning of the following activities to design a QMS: monitoring, checking and evaluation of the implemented system.
3) Planning an Educational System it is necessary to consider interaction between the University and the outside job market creating a "bridge" towards companies which already use a QMS. This is important because these companies could be the workplaces for out coming Engineers.

[1] Podestà, L

Universities are going to change their Educational Systems on the basis of QMS rules called "processes" taking the Industrial Systems as reference, where these processes are in compliance with standard imposed from environmental rules. An example are the ISO 9000, ISO IEC 17025 and other standards [2], [3].

The QMS in university labs is not used as much as it is in other activities e.g. course management, the management stage of evaluation at the end of the course, the administrative aspects related to teaching, the testing phases of the services provided, etc.. This article aims at focusing on the importance of deploying these processes into Engineering University labs, to understand which could be the didactic impact on people who will become an Engineer.

Considering the current economic scenario an important aspect is related to the potentiality that a laboratory could gain in terms of economic independence thank to the use of a QMS. In particular, we think that the creation of a network of laboratories capable of providing various services (relative to the skills of each laboratory) to external costumers, this ensures an economic profit by which they could cope with the current difficulties of fund availability.

These resources could be invested in supporting educational workshops and research, throughout upgrading of facilities in terms of equipment and research staff.

It must also be taken into consideration the important aspect of being able to create a bridge to external companies which can consider the university both as research and working partner.

1.2 Quality within Universities Structures

To explain the concept of quality related to a University structure, among the several used definitions, the following are suitable to represent the purpose (meant as a mission) of a QMS:

- Quality as a set of rules, necessary to reach the expected goal. Quality must define the guidelines for the University mission.
- One of the aim of Quality is the customers' satisfaction, (the customer in this case is every stakeholder) where the customer is intended as any subject who invest in university becoming later a beneficiary of student's knowledge. Customer pool is generally represented by students, their families and industrial partners, as also required in "Guidelines for Programme Assessment and Programme Accreditation" in [4].

Even in an university contest quality must have a dynamic approach intended as: transformation and improvement. Therefore it will be necessary to develop a system capable of facing the fast changes imposed by both current technologies and complex market trend. This aspect is generally approached applying a closed loop method, which consist on reiteration of check and fix error, making then the system dynamic.

1.3 Evaluation of Quality

The processes must be improved to provide better service to customers, to contain costs and timelines, and to become more competitive. To improve a process, it is necessary that all the main quality designers work together to eliminate waste (of money, time, resources) in order to obtain a process which is faster, less expensive, easier and safer, according to the diagram in Fig. 1:

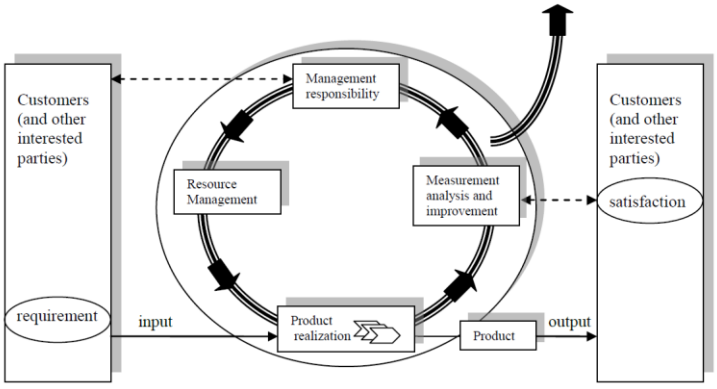

Fig. 1. Example of continuous improvement of a Quality Management System.

It is necessary to try to automate tasks in order to focus on the improvement of at least one of these elements: technical quality, price, delivery time, flexibility, service, staff satisfaction. You can think of a process as a way to achieve a goal, the roads (paths) to reach our goal, however, may be more than one. Improving the process means finding the best route to go. The differences between the performance of a process and the demands of a customer represent opportunities for improvement, as well as the presence of bottlenecks.

In light of the said above, a process will definitely be revised or improved if:

1) there have been changes in the structure of the organization that have an impact on it;
2) the needs of customers in the process have changed;
3) the organization's needs (need to reduce the time / cost, etc.) have changed;
4) the process can not achieve the pre-set results and goals;
5) the operator does not have adequate instructions to perform its own work and he did not receive proper training;
6) the operator can not take advantage of the resources needed to work on the process.

To improve a process means therefore to improve the quality. To do this it is therefore necessary to be able to give a measure of the quality and this can be done by analyzing the following objectives:

1) Improving the satisfaction of our customers.
2) Reducing the costs.
3) Making the organization's performance visible and recognizable to an objective level by everyone (employees, customers, etc).
4) Comparing the performance over time.

There are no established rules to measure performance. There are, however, several ways to "measure" the quality within an organization or in a particular process and to have an objective idea relative to its trend. We can try to use one of the methods listed below or, better yet, to use more than one so that one can be complementary to each other:

a) Self-assessment through a constant and timely collection of the main indicators.
b) Self-assessment through the audits.
c) Review of the Quality Management System.
d) Evaluation by a certifying body.
e) Rating by customers.

However, it is critical to understand how to interact in the best way with a process to improve it according to the deviation that it produces, compared to the expected results.

1.4 Costs related to the Quality Design

The design of a QMS depends on a large number of factors, it is a little how to define a multi-variable function of the type f (x, y, t, ...) in the same way you can think to characterize our Management System Quality as follows: QMS (# of employees, # of processes, # of units, departments' size, implementation time, ...). Each of these variables must be analyzed carefully in order to take them into account in an appropriate way during design phases of the system, and a quantification of the costs.

You can, however, think that there is a common denominator that binds all these parameters. When it changes, all these factors change depending on a certain relationship. We can identify this common factor within the quality objectives established by the board of directors at a stage preliminary to the implementation of the QMS, on the basis in which these objectives are achieved.

By focusing on the first point when defining the objectives the level of quality to be obtained is characterized. It is obvious that the level of quality that you will get will depend on many factors and may deviate in a more or less consistent from stated goals, but this basically depends on how it was

made and the resources made available by a number of factors that need to be put in the account for a correct definition of the measurement and corrective actions.

Here we just want to emphasize that all the parameters that define a QMS find their origin in the definition of quality objectives. You can then, greatly simplifying the discussion, to arrive at a dependence of this type:

$$QMS\ (Q^*) \tag{1}$$

where Q* is the level of quality that meets the requirements.

We do not want in this article to get about the analysis of costs, which must be addressed to implement and certify a test laboratory.

1.5 University Laboratories

For some students of our university courses, the practical approach to some aspects of teaching is of paramount importance. In the past the opportunity to attend educational workshops was reserved for a few situation and contexts, in this reality, many students are left unprepared from a technical/practical point of view.

Lately, with the inclusion of credits related to hours of training in laboratories, this important part of the training is integrated in a more concrete way. The next step should be to give a uniformity of language to training in the workshops, and this could be done with the implementation of the QMS accredited or not for these structures.

In accordance with current regulations, accreditation of a laboratory passes through the implementation of ISO IEC 17025, an European legislation in the field that migrates aspects of quality of ISO 9001 and completes them with regard to the technical aspect and not-only.

2 UNIVERSITY LABORATORIES IMPLEMENTING QMS

2.1 Impact on the university study path through internship or thesis

A curriculum that includes an Internal Training Period, in laboratories that implement processes based on management systems for quality, should be thought as a link between the university and the job market for future engineers.

The goal is to transfer the working methods through processes to the students. This can be done through two different types of path: training periods and thesis for both first cycle and second cycle students.

An early learning opportunity can come from the training activities inside laboratories. At this stage students can learn the basic concepts of QMS and learn to deal with the activities of work and study through an approach based on processes. This step is fundamental because it concerns the fundamental aspect of a Management System (MS) in general.

In the current working scenario we tend, as already pointed out, to deal with any problem/activity through a decomposition into elementary units operated by processes. This often happens even when you are not implementing an MS. The high specialization in various working fields and the need to interact, in all sectors, with other operating units inside or outside the structure, made necessary the standardization of the communication protocols. This becomes much easier with the introduction of the concept of "Process".

This is not the place to emphasize the importance of this instrument, but there is no doubt that we should include its knowledge in the course of study, and this could be done through the Educational Activities "Practices" to satisfy more fully also what is prescribed in the requirement "Engineering Practice" of [4]. This should then be dealt with in all the degree courses of Engineering and not only bound to specific area courses.

The training activities may have a fundamental role in this sense, because being the concept of process contextualized to any work activities, regardless of the type of, it is possible to work transversely to the study plan and provide a step that includes this learning phase.

Another opportunity for the students of the Faculty of Engineering occurs during the period of the thesis. During this work can be a real need to manage a more complex activity that requires

interaction with other working groups, internal or external to the core university. At this stage it is possible to hone skills already acquired and to develop a greater sensitivity that leads students to improve their knowledge by means of a QMS.

Currently at the DIAEE Department of Astronautics Engineering, Electrical and Energy, in the Laboratory of Electronic Measurements, we are implementing a QMS in order to obtain accreditation for the laboratory in the future. In this context, a training program has started, which provides for students willing to perform hours of training at the laboratory, an introduction to the basic concepts of a QMS. All the activities are managed through processes. This as a first step in understanding a different approach to working methods.

Students can also decide to carry out their thesis work in the laboratory, in either case students have done the internship or not. In the first case the student can delve into the issues already addressed and give then continuity to the training, while those who have never experienced QMS, can acquire this knowledge during the last period of training, by a program that starts from the primary notion.

2.2 Implementation

In our Department, we started some experiments, with the aim to better analyze the didactic curriculum we offer.

In the following description, it is shown how basic elements about quality are transferred to students through ordinary activities. These activities are useful for students to acquire a new thinking and operating way applying quality procedures.

The first step to introduce students to the laboratory activities is the explanation of some basic concepts of a QMS. Students learn to work following procedures and rules.

Here are some examples:

Process 1: Choice of a measurement instrument.

Aim: with this process, try to avoid unnecessary downtimes resulting from a superficial choice of instrument, which may result in the invalidation of the measure.

Field of application: all measurements in the electrical/electronic field.

Procedure: in order to identify the most suitable instrument to make a measurement of an electrical quantity, the student must first perform the following steps:

A. Pinpointing the quantity to be measured.

B. Clearly define the range in which to operate, (amplitude, frequency, temperature ....).

C. The level of accuracy required.

This approach requires a careful preliminary analysis of the signal to be measured, and especially the instrument necessary for such a measure. This way of proceeding ensures extremely increased knowledge and mastery of the instrument.

Process 2: Use of equipment

Aim: this process defines the good work practices, both in the laboratory in order to improve the quality of their work, especially as it highlights the following point D.), and for the proper and safe management of the laboratory.

Field of application: all measurements in electrical/electronic field.

Procedure: in order to ensure proper use of equipment, and in accordance with best practices and security measures in a lab, the student must follow the next steps:

A. For equipment (instrument and accessories, i.e. cables and probes) that are initially stored in special closet, the student/operator has the task to collect them and place them on the appropriate measuring benches.

B. For the connection to the electrical supply and all preparations, always the safety instructions indicated by the instrument manufacturer must be followed. Where these do not exist then you will follow the general directions indicated by the laboratory code.

C. If existing, you must always follow the measurement procedures specified in the manual of the instrument. Otherwise the new procedures must be validated by the head of the laboratory, and in any case must be conducted within the limits of "good use" of the instrument.

D. At the end of measuring the student/operator must take care to put the equipment into the closet, in order to ensure their safety and maintain the laboratory in a state of order and cleanliness.

In this way we try to create a bond of respect between the student and the work environment and his colleagues, empowering students through basic tasks.

Process 3: Good work practices

Aim: in this process the principles that help the student to conduct an activity independently are defined, according to good working practices.

Field of application: this process can be applied to the areas of measurement as those of research. It has a general validity as a systematic approach.

Procedure:

A. It is required to present a schedule of the required activity, this may comprise a part of the study, a search part or a part of measurement.

B. It is required, regardless of the type of activity, to write down the activities carried out in electronic format in order to create a "diary" or "historical" of the steps followed to complete the job.

   1. In this way it is possible to perform work linear, avoiding duplication of the same operations, and at all times have a more complete view of the work that you are performing.

   2. In this way the closing phase of the work is for the student more simple especially when this must be accompanied by a written report.

   3. For people controlling the work, it is more direct the evaluation phase especially when you have many students/projects simultaneously.

In this way we try to convey a systematic approach to the conduct of study / practice, through a methodology that often has a strong response in the workplace.

3 CONCLUSIONS

In the last year 3 internships and 6 theses were delivered according to this philosophy. The response from the point of view of the students has been positive, as demonstrated by the fact that the three trainees have done their thesis in the same laboratory. Two of the six undergraduates (bachelor's degree) went straight into working reality, and they rated the concepts learned in our business extremely useful, given that the company they work for implementing QMS (in particular ISO 9001).

Those presented are the basic processes developed and implemented so far for this task. In actual operations of the laboratory every action must be carried out according to a well-specified procedure.

The basic idea is to complete the accreditation of the structure, and in this context the learning activities of students, thus creating a strong connection between academia and job market.

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