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Evaluation of Implementation of Quality Methodologies in the Engineering Institute of UABC in Mexicali

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Abstract: ***This work describes an analysis of the implementation of quality methodologies that generated an improvement in the research, development and teaching activities of the Engineering Institute of Autonomous University of Baja California (EI-AUBC), located in the city of Mexicali. These methodologies are widely used in the industrial sector to prevent accidents, reduce waste, and eliminate rework and to training of workers in any area in the industries. Only that its applications are very little known in the Laboratories of Higher Education Institutions (LHEI) of the Mexican Republic. With this scientific study the results of the investigation activities were more reliability to be take adequate decisions and were made functions with more security taking care of health of researchers and students. The investigation was made in 2019.***

Keywords ***Educational institution, investigation activities, methodologies quality***

I. INTRODUCTION

The development of investigation activities based on quality methodologies generates great reliability in the information obtained from experimental trials, being essential to determine the characteristics of the experiments, and thus apply the continuous improvement tools in an appropriate way (Inês C. et al, 2017). In a large number of activities in laboratories of research institutes, is not follow the procedures indicated in the quality management in experimentation areas, of how to use materials and products, instruments, equipment and machinery, that are similar to be used in educational, commercial and industrial (Ortega G., et al, 2009). All research laboratories require reliable information. But there are some that require that the data obtained be very precise using specific quality procedures, due to the materials used and products obtained, as well as specialized instruments and equipment, to obtain highly reliable results.

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These laboratories are those in the aerospace, environmental, computing, genetics, engineering, medicine, chemistry, and veterinary fields (Presot I. et al, 2014). One of the areas of Mexico where the investigation where has been increased considerably, is in the northwest of the Mexican Republic due to the great economic development that has been generated in the last twenty years. In this region is the city of Mexicali, where the Autonomous University of Baja California is located, having in one of its facilities the Institute of Engineering, and that was inaugurated in 1997 (Ramírez D. et al, 1997).

II. QUALITY STANDARDS

Currently, an increase has been observed in the number of laboratories of higher education institutions (HEI), where test and calibration accreditations based on the ISO / EC 17025 (X5) standard have been applied (Ana S. et al, 2014), with the aim of guaranteeing quality in their experimental tests, only that some not follow its processes. The quality methodologies that are proposed are easy to apply and are of great help to establish quality criteria, in addition to representing an improvement in the way of carrying out the activities. This is with the objective of achieving customer satisfaction whether internal (researcher-teacher-student) or external (society-industrial sector) when an applied research certifications or accreditations under specialized quality standards such as ISO / EC 17025. In service is provided (Ovretveit J., 2013). These can for future this investigation institute, experimental processes are made in various areas, only that on certain occasions they are not elaborated according to the standardized procedures. This is a relevant factor because some activities are risky, such as the use of toxic substances in laboratories in the environmental and chemical areas, or unreliable data are obtained in computing and engineering areas. Based on this, activities with great risk are developed. In addition, erroneous information is generated from real cases of different topics, taking inefficient decisions being made by the research staff, and sometimes speculating on risks that may have a negative effect on the integrity and health of people and materials used in some engineering activities.

III. APPLICATION OF QUALITY METHODOLOGIES

The development of quality systems in laboratories of a higher education institution is different from any other type of laboratory (Frederick S. et al, 2010). The Engineering Institute is a higher education institution that pursues the fulfillment of three main functions (triple duty) of university life: 1) teach, 2) elaborates basic and applied research, and 3) develop routine analysis under contracts with its social and industrial environment (Jena G. et al, 2017). In this investigation, industrial quality methodologies were applied in the Corrosion and Materials and biofilm laboratories, being: the 5'S, inventory control, training within the Industry - Work Instructions (TWI-JI for its acronym in English) and assessment of basic skills (volumetric and gravimetric). The main objective of this scientific study was based on evaluating quality methodologies to:

1. Obtain a pleasant and safe work environment.
2. Reduce search times for materials and chemical reagents.
3. Ensure proper use of specialized laboratory equipment.
4. Evaluate educational competencies in basic operations such as gravimetric and volumetric tests.
5. Train personnel who have the ability to assess the acquisition of analytical skills.
6. Obtain an adequate operational performance in research activities.
7. Have the reliability of the services offered.

It should be noted that the engineering institute is familiar with quality standards, since in past years it obtained certification in the ISO 9000: 2000 standard. In this work, the implementation process of the aforementioned quality methodologies system is presented, which can contribute to the achievement of a future accreditation in the ISO / IEC 17025 standards (Biasini V., 2012).

Importance of using quality methodologies

At present, the concept of quality methodologies in investigation laboratories in the HEI has been established as a competitiveness tool in the educative, commercial and industrial environment, obtaining international accreditations such as ISO / IEC 17025 (Tweedale T. 2010). For higher education institutions this represents an opportunity for acquisition of economic resources of government and private companies, in base of reliability of the results obtained from theoretical and applied research projects. Recent studies show the relationship that exists between the number of laboratories of higher education institutions accredited under the ISO / IEC 17025 standard and the gross domestic product of each country (Andrade E., et al, 2016). In North America, Mexico has the highest percentage of accredited higher education institution laboratories. Having laboratories accredited under a quality standard means of the HEI means those professors who investigates together with postgrade students, which works under a standardized and validated system, where students acquire quality learning. As an institution of higher education, its role in society is the generation of knowledge through research, as well as the training of highly competitive professionals. The engineering institute has made the decision to face this challenge by assuming the responsibilities that the implementation of a quality system entails (Ana S. et al, 2014). The main obstacle she faced was creating quality awareness in each and every user of the laboratories. Quality depended on a joint effort, where the collaboration of each of the departments involved in the process should be had.

Evaluation of research methodologies in the EI-AUBC

In the process of applying quality methodologies, quality groups were formed, elaborated by incharges of laboratories of II-UABC. Also, was realized periodic meetings to plan, detects, analyze and seek solutions to various problem situations in the investigation work areas. With the formation of these groups, personal development and leadership were fostered, and the communication improved. The application of quality methodology in EI-AUBC laboratories was appropriate to reaches the satisfaction of both internal (researchers, students) and external (society and industry) clients. With this, reliable products and services were obtained, to continue the path towards quality in some laboratories of the EI-AUBC and take the first step in others (Zapata, Llaurado, and Rauret 2007). The application of quality methodologies implemented quality in laboratories of this IES, improved the quality of processes and information obtained from experimental processes (Souza R. et al, 2012). In addition, costs were reduced with less rework time, errors and delays. By improving productivity, was offered a best service with high quality and lowest price, multiplying research activities to support the population and industries (Leonelli S., 2018).

Implementation of quality methodologies at EI-AUBC

In previous years, the EI-AUBC has being implemented processes based on the ISO 9000 standard, which what was showed in this investigation, where some laboratories were working under a quality system, using the Good Laboratory Practices (GLP) manual) (Jarvis M. et al, 2016). But others laboratories, required of new quality methodologies. For this reason, some areas were identified as development of opportunities for improvement ((Marino M., 2014). 2013). The analysis of the process elaborated, to evaluate the implementation of quality methodologies was made in laboratories of EI-AUBC, which were made realized in four steps, being mentioned next:

1. Analysis of the quality methodologies selected for each laboratory and evaluates their results (where the process was defined).
2. Awareness and training (believe and know how to develop the activities).
3. Documentation and implementation (how to develop the activities).
4. Measurement and verification results (what to do to make the activities properly).

IV. METHODOLOGY

An evaluation of the application of quality methodologies (Anderson T., et al, 2012) was developed in the II-UABC Corrosion and Materials Laboratory, analyzing the stages of preparation and handling of chemical materials. The study was carried out in three stages that are explained below:

Step1. Development of model that represented the application of quality methodologies in the EI-AUBC .

Step 2. An analysis of the quality methodologies implemented in this laboratory was made to evaluate the way in which the research activities were carried out, regarding the monitoring of the functions of each person and the use of chemical reagents in the experimental processes. At this stage, a didactic instrument with matching questions was used to obtain the required information in order to determine if quality methodologies were being properly applied.
Step 3. The information obtained from the didactic instrument was evaluated to find out how to develop the research activities, to corroborate whether the application of quality methodologies was being monitored in this laboratory.

Step 4. Once the information had been analyzed, it was detected on the part of the graduate students, the stages in which the quality methodologies were not followed, shown as information organized in tables and graphs to observe the situation in greater detail of what was happening in this laboratory regarding the application of quality methodologies.

V. RESULTS

This study was made to evaluate the quality methodologies applied to EI-AUBC laboratory research activities, observing that researchers and postgraduate students in the area of corrosion and materials and biofilms, where this scientific analysis was focused, most of Their functions were made according to quality procedures and only in some cases of observation, it was detected that they did not follow the quality procedures on the part of the students. This generated concern on the part of the person in charge because sometimes there were some anomalies in the organization of materials and methods of carrying out activities, causing certain risk situations such as the handling of chemical reagents such as acids that, if not properly handled, can cause a serious health problem.

Model of implementation of quality methodologies

This is described and explained at detail below. In step 1, was made a selection of the quality methodologies required in each laboratory at EI-AUBC, according to their needs, evaluating each activity and obtaining reliable results (Figure 1). The step 2, consisted of informing to users of laboratories of the EI-AUBC, about the importance of applying these quality methodologies in their workplace, as well as the benefits in their personal safety, working in a safe space and being effective in their functions. In this step was evaluated the training meetings, which were scheduled periodically, were also analyzed, as well as the sensitization of the working activities of each laboratory users. The quality methodologies procedures were also evaluated at this stage, with respect to visiting researchers, or any other person outside the EI-AUBC, to practice the selected quality methodologies (Mathur-De Vré, 1999). In step 3, were developed activities that were made within the laboratories to obtain information on the experimental processes to be documented. In addition was made analysis to defining responsibilities and identifying those responsible for each research activity. In step 4, verification controls were established through periodic reviews in the EI-AUBC laboratories, through checklists and surveys carried out to obtain information that would be supported to apply continuous improvement in each laboratory. Based on evaluations of the application of quality methodologies in the Laboratory of Corrosion and Materials and Biofilms of the EI-AUBC, a model was developed that is represented in figure 1. This representation illustrates the methodologies applied in the way of elaborates the investigation activities of part of researchers, postgrade students and students of professional practices in this laboratory, evaluating the procedures that are based on methods applied in the commercial, educational, industrial and social sectors.

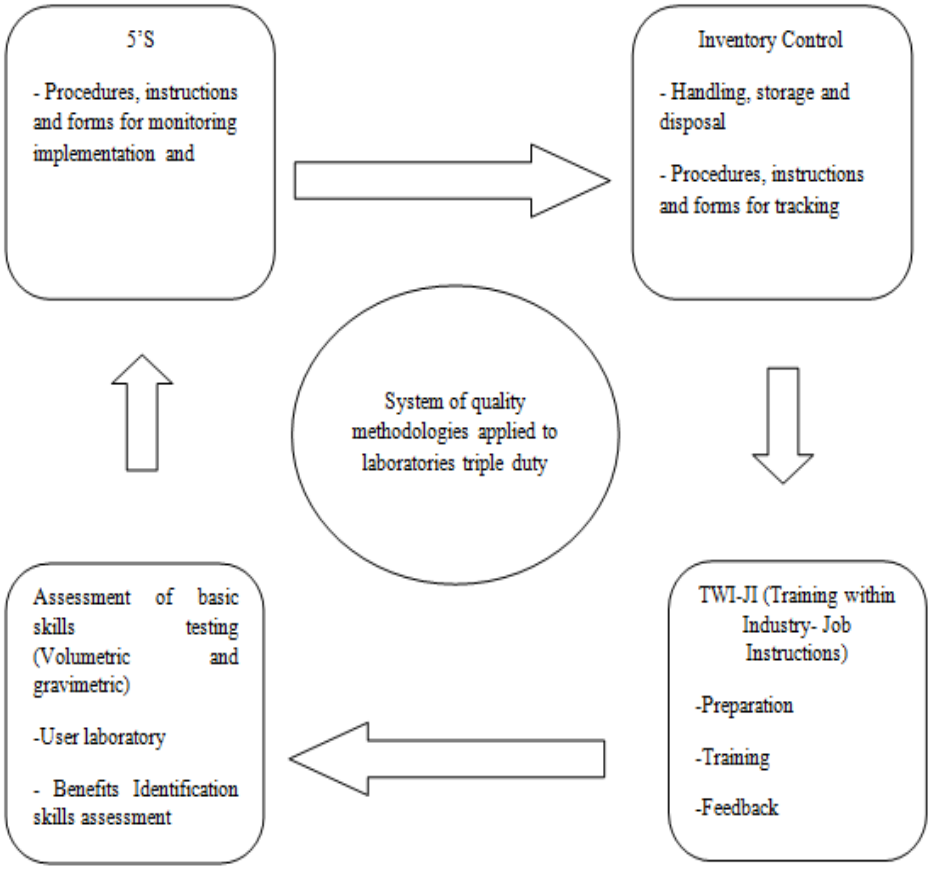

Figure1 System of quality methodologies implemented in the EI-AUBC

Evaluation of investigation activities

In the elaborated analysis, various types of evaluations of the information obtained in the application of the instrument were developed for the collection (questionnaire). These are opinions of postgrade students (PS) and students of professional practices (SPP), in laboratories of the EI-AUBC of this institution of higher education, being a representative sample of 100 people evaluated. The period of analysis with the instrument to obtain information was in 2018. With this, was observed the way in which the students that was working in investigation activities in the EI-AUBC. This was relevant, to apply continuous improvement in the experimentation processes, especially to obtain reliable information and in the management of dangerous chemical reagents. The opinions of PS and SPP obtained from evaluations made in 2019 are shown in tables 1, 2 and 3, observing that postgrade students had a greater awareness than students of professional practices, regarding the knowledge of the methodologies of quality applied in laboratories of this IES, representing the important factors of this evaluation in the lower part of table 1.

Table 1 Knowledge assessment of quality methodologies

Evaluations	E1		E2		E3		E4		E5	
Students	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
PS	23	12	27	8	19	16	25	10	26	9
SPP	42	23	48	17	37	28	42	23	41	24

E1 Development of activities with adequate environmental conditions in the IES laboratory.
E2 Problem situation analysis and use of brainstorming in IES research activities
E3 Knowledge of quality methodologies procedures in IES laboratories.
E4 Application of quality methodologies in IES laboratories.
E5 Experience in developing experimental processes

The table above illustrates how the surveyed personnel with more experience in research activities, which are the EP, generated opinions with greater certainty of knowledge of the quality methodologies applied in the EI-AUBC, whereas the EPP were on a smaller scale the that they had the knowledge of this important aspect to elaborate the research activities.

Regarding the obtaining of information from the experimental processes, a similar trend was observed in Table 2 to that observed in Table 1. Regarding the relationship of the opinion of graduate students and internship students Professionals, the PE with more experience in research activities, showed greater awareness in the application of quality methodologies in EI-AUBC laboratories, illustrating the numerical data with the most relevant factors in the later section of Table 2.

Table 2 Information analysis of experimental processes

Evaluations	E1				E2			E3			
Students	SF	MP	GI	FM	OR	CS	ER	PV	FV	WE	NE
PS	11	10	14	18	6	7	4	13	5	9	8
SPP	23	16	26	27	15	13	10	16	13	17	19

*SF. Importance of scientific factors, MP. Monitoring of policies and organization, GI. Generation of impact in the commercial, educational, governmental, industrial and social sectors.
* FM. Follow-up to quality methodologies procedures, OR. Constantly observe results, * CS. Compare with other scientific studies, ER. Elaborate lot repetitions.
PV. Analysis of participating variables, FV. Factors that affect participating variables, WE. Way of elaboration of experiments, NE. Number of times of elaboration of experiments.
E1 Criteria used in research activities.
E2. Analysis of validation of information from investigation activities.
E3. Criteria for validation of information on investigation activities.

Table 2 represents an analysis of opinions of the EP and EPP, noting the same trend as the previous table, with regard to the information collected with the didactic instrument, of the importance in obtaining relevant data from experiments. This presented greater awareness on the part of graduate students than those who did professional practices. The information analysis of the criteria used in experimental processes are indicated in Table 3, observing that the thinking of the PS was to obtained learning of scientific concepts and generate solutions in the commercial, educational, industrial and social sectors. This represented a change the students of professional practices elaborated their activities to obtain a significant learning in their professional training.

Table 3 Evaluation of criteria in experimental processes

Evaluations	E1				E2			
Students	OI	PE	EV	IM	GC	IC	CE	CR
PS	15	8	8	4	13	9	7	6
SPP	29	21	9	6	26	23	8	8

* OR. Objectives of research activities, PE. Planning in design of experiments, EV. Evaluation of the most important variables, SM. Use of specialized measuring instruments.
* DC. Degree of reliability, IS. Information from scientific analysis or technological development, EC. Analyze educational competences of research activities, CR. Compare results with previous studies.
E1. Aspects considered in experimental processes
E2. Reliability analysis of results obtained

The information illustrated in Table 3 is relevant because it is observed that both graduate students and internship students agreed that they did not have the necessary knowledge of the criteria considered in experimental processes, only that the PS had a greater interest in obtain the learning of this information.

Analysis of quality methodologies in research activities

In this section, two evaluations were developed with respect to the quality methodology in the EI-AUBC laboratories, observing the evaluations in figures 2 and 3; where in figure 2 a graphic representation of the amount of PS and PPS that they had knowledge is shown of the quality methodologies where they developed their research activities, and Figure 3 indicates that they use these methodologies were used by PS and PPS. In both graphs the representations indicated that not all students know and apply of the quality methodologies, being the responsibility of researchers in each laboratory of this EI-AUBC.

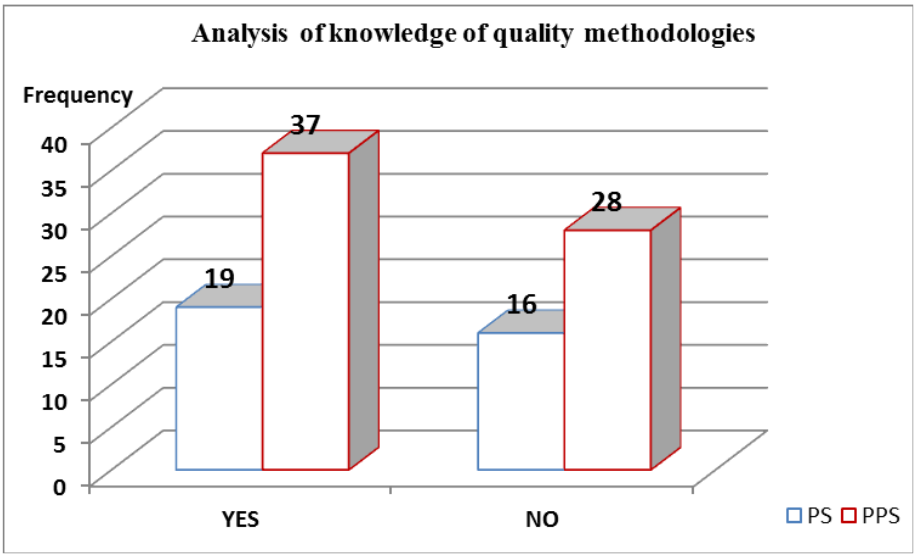

Figure 2 Representation of PS and PPS that know about quality methodologies in EI-AUBC

It is observed in the two mentioned figures that the amount of PS and PPS was greater, both of those who know the procedures of the methodologies, as well as the PS and PPS that applied them to obtain reliable results in the experimental processes.

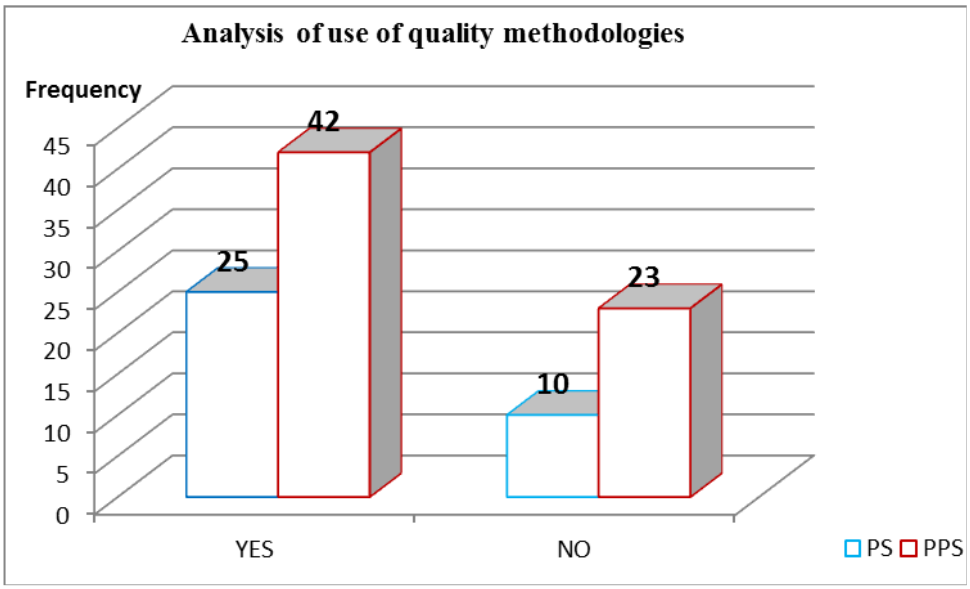

Figure 3 Representation of PS and PPS that use quality methodologies in EI-AUBC

VI. CONCLUSIONS

When quality methodologies were implemented in research laboratories, experimental processes are developed in which the appropriate functions for the validation of results are efficiently determined and reliable results are obtained, managing to observe in greater detail what happens in each situation analyzed. With this, possible solutions can be determined appropriately. The study developed at the EI-AUBC reflected the situation that arose at the time of the research, evaluating the application of quality methodologies in the Corrosion and Materials and Biofilms Laboratory, observing that in this laboratory the researchers, postgraduate students and students of professional practices, met in the evaluation period at a level of 90%. In addition, it was shown that PS had better knowledge and awareness in the use of quality methodologies than PPS, mainly in the development of chemistry experiments and the use of chemical reagents, especially those that generate a risk to the health of the people who participated in the research activities.

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