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Impact of implementing quality control systems in laboratories associated with teaching and research institutions – The case study of the laboratory for macromolecules and colloids in the petroleum industry

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Abstract. The competitiveness between institutions and companies generates the need to cheapen products and services and facilitate their production. Thus, several companies establish partnerships with specialized university laboratories in order to promote the optimization of their processes. These laboratories, in order to guarantee their reliability, often resort to the application of technical standards and the obtaining of international certifications. This paper aims to discuss the relevance of international certifications by research laboratories by report a case study from a laboratory of the Federal University of Rio de Janeiro. The results of the implementation of the quality management system of Laboratory for Macromolecules and Colloids in the Petroleum Industry (LMCP) are presented, where excellent satisfaction results were obtained, as well as a very small number of failures, demonstrating that the system is effective, which generates more and more customers and carry out increasingly sophisticated research. As perspectives it is expected that the quality management system can increase the number of collaborations and high-quality service delivery between industry and the LMCP.

Keywords: University laboratories / quality management system / standardization / integrated management system

1 Introduction

Business competition requires managers to seek ways to reduce costs while improving the efficiency of the use of resources and increasing the production capacity, besides satisfying customers' needs, in a process of continuous improvement [1]. One of the ways to reduce costs is to standardize processes, which fits with introducing innovations in quality, optimizing methods, assuring timely delivery and respecting work safety rules [2,3].

Standardization can be defined as the application of standard practices to a production cycle with the aim of optimizing each step, to stabilize the product or production process, based on compliance with what is prescribed [4]. Furthermore, standardization allows an organization to become more competitive, by making routines safer and more standardized, besides facilitating the implementation of new technologies and stimulating innovation and optimization of processes [5].

In order to gain or maintain competitive advantages over other institutions, innovation plays a key role for many companies. However, few institutions are able to generate innovations on their own [6], especially in developing countries that need to develop and/or apply new technologies in order to improve the cost-effectiveness of their materials and processes, make the best use of natural resources and compete in international markets [7]. Thus, there is a need to create cooperation with external sources of knowledge such as customers, suppliers, technology centers, competitors, and especially with universities [8], which are reference places in research and innovation [6,8] resulting in reciprocal benefits for both sides. In this way universities develop much of the

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technology needed by companies, and in return receive investments to improve their infrastructure [9]. Therefore, with the establishment of academic-business partnerships, many institutions have started to require their associated laboratories to obtain international certifications of the quality of their instruments and reliability of their results [10].

The main objective of this article is to discuss the importance of standardization as well as implementing quality management systems and obtaining international certifications by university laboratories, by describing the case study of the Laboratory for Macromolecules and Colloids in the Petroleum Industry/Federal University of Rio de Janeiro (UFRJ).

2 Literature review

2.1 Regulatory standards and technical standards

In Brazil, regulatory standards (*normas regulamentadoras* – NRs) are documents that cover occupational health and safety, and are mandatory in organizations in the private and public sectors, as set forth in the Consolidated Labor Law (the basic Labor Code, *Consolidação das Leis do Trabalho – CLT*). Disrespect for occupational health rules and laws can generate different degrees of penalties, ranging from warnings to fines and even interdiction of activities [11].

According to the Brazilian Association of Technical Standards (*Associação Brasileira de Normas Técnicas* – ABNT) [12], a technical standard is a document established by consensus and approved by a recognized body that stipulates guidelines or characteristics for activities or their results, seeking to establish an optimal level in a given context.

Vargas [13] states that the main objectives of technical standards are: simplification of procedures; interchangeability of ideas and processes; communication and rational adoption of symbols and codes, generating cost and time savings; maintenance of occupational health and safety and final results; and reduction of commercial barriers and increasing the interest of consumers.

Article 5 of the Brazilian Constitution establishes that "nobody may be obliged to do or refrain from doing something other than by virtue of law" [14]. Therefore, unless a law dictates the contrary, the use of technical standards is not mandatory in the country. In parallel, however, Article 39, numeral VIII, of the Consumer Defense Code establishes that: "It is forbidden for suppliers of products and services to place in the consumer market a product or service that is in discord with the standards issued by the competent official bodies, or if specific standards do not exist, by the Brazilian Association of Technical Standards – ABNT, or another Entity accredited by the National Council for Metrology, Standardization and Industrial Quality – CONMETRO" [15].

The implementation of standardization is the search for conformity of processes and products, with the objective of increasing the efficiency of economic activity. This search affects several fields of action, and implies aspects such as innovation regarding the diffusion of technologies within and between industries [16]. According to Hu et al. [17] the effectiveness of the implementation of regulatory standards can be achieved through the analysis of various indexes, such as reducing the energy bill, reducing production costs and waste, reducing CO_2 emissions, among others.

Due to the high competition between organizations and due to the financial crisis, institutions and companies need to serve their customers efficiently, solving problems faster, with better quality and reduced cost whenever possible. In this way more and more these institutions have resorted to the implementation of management systems to improve their processes, in quality, environmental, safety and occupational health management, among others [18]. Of these management systems, the most internationally recognized are ISO 9001 (Quality Management System), ISO14001 (Environmental Management System) and OHSAS 18001 (Health and Occupational Safety Management System) [19].

2.2 Quality

According to the International Organization for Standardization (ISO), in its technical standard ISO 9000, quality is "the degree to which a set of inherent characteristics of an object fulfills requirements, i.e., meets the intended performance level, also including the value and benefit perceived by customers" [20]. This theme is fundamental for organizations in questions related to strategic planning and ongoing improvement, to maximize sales and profits. For consumers, the quality of products and services is a measure of safety and reliability in comparison with others, which is also important for businesses since consumers tend to be loyal to suppliers of high-quality products and services. Finally, for regulators it assures conformity, protection of consumers, transparency and fair competition [21].

The organizations that apply quality concepts and tools use statistics as instruments to measure quality. They use quality management systems (QMSs) as an option for managerial guidance, generating sustainable development initiatives, thus requiring strategic decisions for the advance of these management systems [22]. A QMS involves planning, controlling and keeping constant improvement of products and processes, based on policies and objectives established by managers [23,24]. The underlying principles are: customer focus; leadership; engagement of people; adoption of the process approach; constant effort to resolve problems and reduce errors (improvement); evidence-based decision making; and relationship management [20]. Therefore, the quality tools are intended to improve the quality of processes, products or services. Among these tools are control charts, cause-effect diagrams (Ishikawa), dispersion graphs, histograms and flowcharts, besides others [22].

According to Junior et al. [25], one of the ways to improve organizational competitiveness by optimizing the quality of products and services is to implement a quality management system according to ISO 9001, associated with the international technical standard ISO 9000. ISO 9001 is one of a family of technical standards that address the implementation and operation of quality management

systems, focused on the prevention of nonconformities, including the requirements to adopt corrective and preventive measures [23]. The family is composed of three standards [20]:

ISO 9000–Describes the fundamental concepts and principles of quality management;

ISO 9001–Specifies the requirements of quality management systems;

ISO 9004–Provides guidelines for better efficacy and efficiency of quality management systems.

Besides these, it is important to pay heed to the ISO 19011 standard, which provides guidelines regarding auditing of quality and environmental management.

In particular, the adoption of a quality management system as specified in ISO 9001 is a strategic decision for an organization to improve its overall performance and establish a solid base for sustainable development initiatives [20]. An organization can implement ISO 9001 even without obtaining certification from a certification company, since this is not a requirement of the standard, if there is a desire to improve the efficiency and effectiveness of operations [22]. However, if there is a perceived need for a seal of certification, the organization will have to demonstrate compliance with the requirements of the standard based on an independent audit [26].

It highlights that the success or failure of the implementation and maintenance of a quality management system depends on the leadership commitment to improving quality, as well as the level of commitment, training and improvement of employees [24]

The Integrated Management System usually links two or more management systems, such as ISO standards for quality, environmental, health and safety management [27]. It is highly effective for organizations to achieve their social, environmental and economic objectives, thus achieving their sustainable development [3], since the integration of management systems generates more efficient and effective processes, in addition, to significantly reduce bureaucratic aspects and increase the monetary health of the organization by reducing costs and saving money [28].

2.3 Accreditation in Universities

Universities, besides training specialized professionals, play a fundamental role in the generation of technical and scientific knowledge and innovation promoting the socioeconomic development of a country, a mission that is enhanced by having the proper equipment, better services and qualified human resources. This mission is especially important in countries considered to be emerging, such as Brazil [29]. The generation of knowledge and innovation is an ongoing process that is nonlinear, and is often achieved through interaction between the university and the society due to partnership arrangements with other institutions and companies. The need for such cooperation is increasing due to the rising costs of research development activities combined with the reduction of public funding and the smaller distance between innovation and application, the last of which depends on the level of technological maturity [30]. The shortage of funding and increase in the number of requests for technological analyses and tests has prompted growth of the number of university laboratories that are willing to perform services for external institutions and other customers, in turn leading governmental bodies to recommend that these laboratories obtain accreditation according to the ABNT NBR ISO/IEC 17025 standard (accreditation of laboratories). One of the first official bodies in Brazil to recommend this accreditation was the Ministry of Agriculture, Livestock and Food Supply [10]. Other similar entities have since also urged accreditation, such as the São Paulo State Environmental Secretariat (SMA), according to Resolutions 37 and 90 [31].

Due to the competition for external demands, given by customers expectations for excellence in quality, educational institutions realized the need to raise awareness about quality aspects, which led to the search for laboratory accreditation [32]. The accreditation of testing and calibration laboratories is carried out by a qualified and impartial entity by confirming the satisfaction of the requirements of a determined standard [33]. Among the advantages of accreditation are improvement of processes, more reliable results, achievement of a competitive advantage over non-accredited laboratories, faster identification and solution of problems, increased skills of technicians and other staff members, and greater satisfaction of customers [21]. Evidence of these benefits can be found in MIDDLEBROOK [34], revealing that accredited laboratories produce better results and face fewer complaints than non-accredited laboratories.

According to Sacramento [35], laboratories at technical schools and universities help mold and guide students for the job market. The reason is that academia and industry often have a relationship of technological interdependence whereby universities develop new technologies and concepts and industries use them to prosper [36]. Professional qualification is one of the important themes to be considered by laboratory managers, and it gives greater security to the laboratory and its peers and reduces environmental risks [36].

The implementation of risk management systems in universities is a concept that has been discussed and applied. Nowadays, after a series of severe accidents around the world raised awareness of the risks of laboratories. Many of these accidents can be attributed to the perception that while risks exist in laboratories, they are much milder than those associated with large-scale operations, even though university research labs have various hazardous substances that pose extremely relevant risks [2,36]. For example, mention can be made of the many problems involving the storage of reagents and other chemical products without proper specifications in laboratories, together with lack of planning, control and training of staff, leading to injuries and materials damages [37].

Although the main role of laboratories connected to universities is not to render testing and/or calibration services, they can obtain advantages from the diffusion of the concepts associated with quality management systems [30]. Among the principal advantages of implementing such systems in research laboratories are increased credibility of

results and researchers, more reproducibility of published results, greater ease of obtaining financing, and improved health and safety of personnel [38].

3 Case study of application of an integrated management system in a laboratory

3.1 The context: Federal University of Rio de Janeiro (UFRJ)

Federal University of Rio de Janeiro (UFRJ), founded in 1920, is a very relevant institution for teaching, research and extension in Brazil. According to a survey conducted by US News Education, comparing the best universities in South America in 2017, UFRJ was in third place in the ranking of the best 59 universities, confirming its importance to the country [39].

Regarding structure, UFRJ has three campuses, which are divided into centers, and these into institutes and schools/faculties and supplementary entities. Nowadays this structure served more than 55,000 undergraduate students and 11,000 graduate students [40].

The Alberto Luiz Coimbra Institute of Graduate Studies and Research in Engineering (COPPE), connected to Federal University of Rio de Janeiro, is the largest center for teaching and research in engineering in Latin America. Founded in 1963, it was a pioneer in graduate education in Brazil, graduate more than 13 thousands of master's and doctoral students in its 14 graduate programs. Among Brazil's engineering schools, its programs have received the largest number of maximum scores given by the Office to Improve University Personnel (CAPES), part of the Ministry of Education, and its performance is considered to be equal to the most important teaching and research institutions in the world [41].

In 2010, COPPE created a program for an integrated management system to certify its laboratories according to the standards NBR ISO 9001 (Quality Management System), NBR ISO 14001 (Environmental Management System), and BS OHSAS 18001 (Occupational Health and Safety Management System) [42]. It happens due to most of the laboratories of UFRJ did not have any management system implemented according to international standards. However, to establish partnerships with large companies in the energy and oil and gas sectors, these arrangements had to follow Resolution 6/2005 from the National Petroleum, Natural Gas and Biofuels Agency (ANP). The Resolution 6/2005 requires that the research institutions with which it forms partnerships must have systems for management of quality, occupational health and safety and environmental protection implemented according to international standards. The creation of the integrated management system of COPPE led to the creation of Quality Management Support Service (COPPE-Q) and a standard (Self-Audit).

COPPE-Q has the general objective of assuring the qualification of professionals and certification of the products and services of Brazilian university laboratories with respect to quality management systems, based on the international standards NBR ISO 9001:2015 (Quality), OHSAS 18001:2007 (Occupational Health and Safety) and NBR ISO 14001:2015 (Environmental Management). It offers courses, audits of management systems and certification of installations and products (including through the Self-Audit program), besides participating in national and international standardization forums [42].

The Self-Audit program vouches for the self-declaration of compliance of laboratory installations and the related management systems with international standards by leaders who take the training offered by COPPE-Q. Since its advent, more than 100 installations have been certified, among which are the Laboratory of Polymerization Engineering (ENGEPOL), Laboratory for Macromolecules and Colloids in the Petroleum Industry (LMCP) and the Interdisciplinary Group of Interfacial Phenomena (Grifit), all belonging to UFRJ. The Self-Audit certificate is recognized by the ANP, and is scaled in seven categories, according to the following criteria: Preparation of Management Systems; Implementation of Management Systems; and Ongoing Improvement of Management Systems [42,43]

Among the laboratories of UFRJ accredited according to ISO 9001 is the Laboratory for Macromolecules and Colloids in the Petroleum Industry (LMCP), which has also had Self-Audit certification since 2015.

3.2 The laboratory case study: the laboratory for macromolecules and colloids in the petroleum industry (LMCP)

The LMCP was created in 1995 to meet the growing demand for polymeric additives for exploration and production of oil and gas. Its installations are located at the Institute of Macromolecules (IMA) of the Technology Center of Federal University of Rio de Janeiro. The laboratory is a venue for investigation of the synthesis and chemical modification of polymers, characterization of synthesized polymers and commercial polymers, and studies of their properties in solution, with the objective of assessing their specific performance in E&P activities [44], producing several relevant works such as Vianna et al. [45], Lucas et al. [46] and Alves et al. [47].

Among the partners and customers of the LMCP are Petrobras and companies that render technological services and supply products to the petroleum industry, regulatory authorities, and other institutions of higher learning. These partnership activities and sale of services bring various benefits, such as purchase of new equipment and inputs financed via partnership projects, hiring of specialized technicians and researchers, offer of scholarships to students, and payment for participation in courses and congresses by the laboratory's researchers. This makes the research of the laboratory increasingly precise and broader in scope, which burnishes the reputation of Brazilian science, bringing benefits to the population at large. These benefits are discovery of new technologies with improvement and reduction of the costs of existing ones. They observed a reduction of environmental impacts in oil spills using nanocomposite of recycled polymer matrix [48]

and, on the other hand, the optimization of oil production and transport by reducing the pour point and inhibiting the formation of paraffins in the pipelines [47].

4 Material and methods

The methodology for implementing the quality management system within the Laboratory of Macromolecules and Colloids in the Petroleum Industry will be explained below. The hierarchical structure, the ABNT standards that were used and the practices adopted for implementation impact on the excellence of laboratory quality management is discussed.

4.1 Hierarchical structure of the LMCP

The hierarchical structure of the laboratory management system was organized based on the hierarchical levels of positions within the laboratory:
– Head of the laboratory.
– Professors-Researchers.
– Researchers.
– Technical Professionals.
– Interns.

4.2 Standardization

The standardization in LMCP facilities is based on the standards NBR ISO 9001:2015 as well as requirements for preservation of the health and safety of staff, prevention of environmental pollution, and satisfaction of the needs of customers [49].

Because the laboratory is part of a teaching and research center, various undergraduate and graduate students work in its facilities. To maintain the quality and safety standards, before starting their activities all the staff members of the LMCP (students, lab assistants, researchers) must undergo training (briefing), in which the quality and workplace safety standards are presented along with some procedures that must be followed inside the facilities. In addition, to refresh and heighten awareness of these concepts, the laboratory promotes periodic presentations, courses and training sessions in health, safety and environmental responsibility, as well as debates and meetings on the evolution and changes in the Integrated Management System (IMS).

To guarantee and evaluate the efficacy of the management system in a company or laboratory, quality indicators are typically used to monitor performance [50]. In this respect, the LMCP uses several Key Performance Indicator (KPI) to measure the ongoing improvement of the system, the overall satisfaction of customers, satisfaction of delivery punctuality, number of reports returned (for corrections identified by customers), number of new customers, number of equipment failures and number of training courses and/or participation in congresses by staff members.

The customer satisfaction survey is carried out using the free Google Forms Platform, from the company Google. Customers are asked to answer the following questions:
–Company name
• Free answer
–Type of Service
• Free Answer
–How did you get to know the laboratory:
• Indication
• Internet
• Congresses, lectures or events
• Others
–Are you satisfied with the timely delivery of our results?
• Scale from 0 to 5 (0–Totally dissatisfied; 5–Totally satisfied)
–What about technical assistance?
• Satisfied
• Dissatisfied
–How confident are you in our results?
• Scale from 0 to 5 (0–Totally dissatisfied; 5–Totally satisfied)
–What about the overall satisfaction regarding our service provision?
• Scale from 0 to 5 (0–Totally dissatisfied; 5–Totally satisfied)
–Suggestions and/or Complaints:
• Free text.

The data is processed and the answers "Totally satisfied" are considered as 100% satisfaction and "Totally dissatisfied" as 0% satisfaction. The final result of the satisfaction indicators is given as the average of all the answers obtained for a given year. This case study shows results from 2015 to 2020.

5 Results and discussion

5.1 Hierarchical structure

The hierarchical structure of the LMCP is depicted in Figure 1. The Leadership is in charge of three sectors: the Quality Division (responsible for maintaining the quality standards); the Technical Division (responsible for planning and technical decisions); and the SUB-IMS Team (responsible for providing critical information on the activities of the laboratory to new staffs (briefings), overseeing the staff and notifying the Leadership of nonconformities). Below these is the Operational Area, responsible for the research and testing activities, connected to the Administrative Secretariat, responsible for relations with employees, customers and suppliers.

5.2 Practices described in briefing

For the entry of new employees, as mentioned above, a briefing is held and this briefing was built with the intention of informing and detailing for all people who attend the laboratory internal standards, which were based

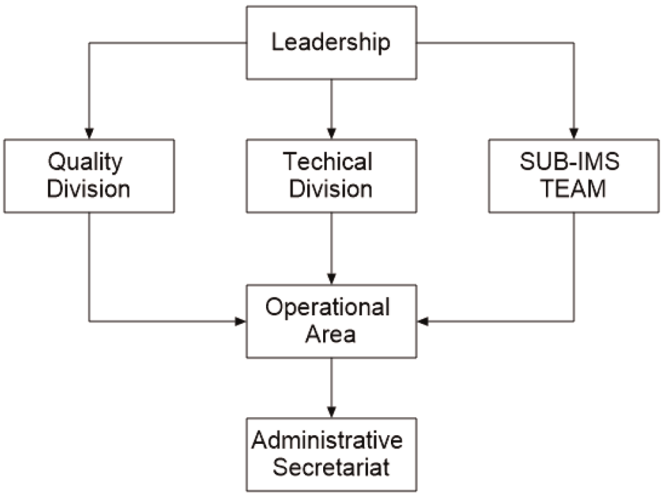

Fig. 1. Hierarchical Structure of LMCP.

on care with the quality of the tests, according to ABNT NBR ISO 9001:2015 standard, and environmental and occupational health and safety practices.

The internal rules and good practices applicable to the laboratory are:

- Only staff members who have concluded the institutional training can enter the laboratory facilities;
- All people in the laboratory facilities must use personal protective items (closed impermeable shoes, apron, goggles and/or mask, depending on the chemical products manipulated and equipment used);
- All solid wastes are separated into oily and non-oily material, with disposal carried out by a specialized company;
- All liquid wastes are separated by chemical nature, with disposal carried out by a specialized company;
- When staff members are not present, the respective laboratory facility is kept locked with the equipment turned off (when possible);
- Groups of fire extinguishers (CO_2 and chemical powder) are located strategically just outside each laboratory facility;
- Staff members who witness a nonconformity in the activities of others must notify the higher authorities for the proper measures;
- Any time members need to conduct a test/analysis or use an apparatus with which they are not familiar must ask the secretary to schedule training with the technician in charge;
- Each piece of equipment has a Use Control and Fault Identification Log (RE-CUIF), where the staff member identifies, among other information, his/her name, date of the procedure and any failure in using the equipment;
- Each piece of equipment has an Equipment Use Permission Log (RE-PUE), to keep track of the people who are authorized to use it, after undergoing the proper training on the handling of the equipment.
- All accidents and incidents must be reported immediately to the Upper Management, and depending on the case, the fire brigade and/or local fire department must be contacted;
- All chemical products in inventory must be recorded in a stock control spreadsheet, with indication of the lot number, validity (use-by) date, and items necessary to carry out analyses and tests, to assure the quality of the results, as well as entry and exit of materials;
- As a security measure against COVID 19, in 2020, social distancing was implemented, as well as work schedules, so that there is a minimum of people working, as well as the installation of alcohol in gel towers for hand asepsis.

To assure that the standards and good practices are being satisfied, there are regular internal inspections by the SUB-IMS and Upper Management. If a nonconformity is noted, the person responsible for it is notified by e-mail. If a staff member receives three nonconformity notices, he/she must undergo specific refresher training before returning to normal activities.

5.3 Key performance indicator

The Management System of the Laboratory for Macromolecules and Colloids in the Petroleum Industry is applied to the tests carried out in the permanent installations of the LMCP, including separate laboratory facilities for synthesis, testing and instruments. It also applies to the tests carried out in other laboratories of the IMA by professors associated with the LMCP.

The quality of the services provided by the LMCP after the implementation of the quality management system are presented in Table 1, where the KPI analyzes for the year 2015 (start of control) up to the year 2020 are found.

Table 1 shows that the overall satisfaction of customers is greater than 90%, and satisfaction with punctuality (Satisfaction on delivery) and reliability (Satisfaction with confidence) of results has been increasing in 2016–2018. In 2019, this indicator decreased due to the delay in communicating progress and delivering results to a client. This was due to a test of modification of analysis compliance protocols. Since the laboratory is committed with continuous improvement, a non-conformity communication was opened in order to report, resolve and propose corrective actions for this complaint and, thus, improve the management system of the laboratory with respect to the customer satisfaction indicator. Immediately, the agile techniques OKR (Objectives & Key Results) and SCRUM were applied, and a meeting was held, in which a verification of the entire procedure was carried out and a corrective action was planned in two stages. The first step was a critical analysis meeting after receiving unsatisfactory research, to identify the causes related to this client's response. And, in this meeting, the fact was highlighted by an information that this complaint arises from the fact that we use a subcontract from another laboratory to perform part of the service. This fact limits the control of the service, as the deadline may not be met by the outsourced laboratory. As a corrective action, it was decided to assess in a special way the need for future hiring on an outsourced basis, devoting more time in meetings to outline new strategies and greater time to assess the need for future subcontracting and, if there is no possibility of delivering the results within the required time, decline the requested

Table 1. Key performance indicators of Management system of LMCP.

Year	Overall satisfaction (%)	Satisfaction on delivery (%)	Satisfaction with confidence of results (%)	Number of new customers	Percentage of failures (%)	Number of training courses and / or congress participation of the LMCP collaborators
2020	100	96.7	96.7	3	4.6	5
2019	88.5	82.8	91.4	3	1.8	18
2018	94.3	97.1	97.1	7	3.8	18
2017	92.0	84.0	98.0	3	2.1	9
2016	96.0	80.0	92.0	2	3.6	6
2015	–	–	–	3	8.2	–

service. The second step was to explain to the client about the new service acceptance policy, the procedures that must be performed and the deadline for delivering results. The corrective actions were based not only on going beyond the analysis of the process itself, but also on the general scope of the management system. Other training sessions were held for all activity supervisors and project coordinators on how to fill out forms, avoiding the inclusion of misleading data of documented information for all activity supervisors and project coordinators, as well as the application of the technique Kanban when using task souvenir tickets. In this way, the weakness that has hitherto been related to sending quick responses to the client has been reduced, mainly information about the progress of the service, as well as the characteristics and difficulties of working with the sample sent by them.

After the training and corrective actions were carried out, the maximum value of global customer satisfaction was obtained, demonstrating the effectiveness of the laboratory's integrated management system and its antifragile leadership.

In another indicator, Percentage of Failures, it can also be seen that the rate of equipment failures has been lower than 5% since 2016, likely due to simple solutions in the organization and implementation of the system. Such as (i) better control of the people authorized to operate equipment through registration in the RE-PUE, (ii) increased participation of staff members in training courses, (iii) better preparation of staff members to give internal training to other staff members about the use of equipment and conduction of procedures; and (iv) registration of equipment failures, allowing constant monitoring, thus reducing the response time for maintenance. Another important aspect is that despite Brazil's serious economic difficulties in the period covered by this report, the number of customers requesting analyses, tests and other services (number of new costumers' indicator) increased. Furthermore, the larger base of new and existing customers led to increased participation of staff members in external training courses, such as instruction for members of the fire brigade and participation of researchers at congresses and other events that promote training and engagement in the activities of the laboratory.

When looking at an increase in the number of failures in 2020, it has to be due to the financial crisis experienced in Brazil, transfers to laboratories were greatly reduced. So, with the remaining funds, it was impossible to carry out periodic maintenance on all equipment. In addition, there was a change in the power supply by the electric company, which caused some inconvenience during power peaks. In this way, a UV-vis equipment, which was used for tests, presented failures and, on a given day, several tests were carried out, but none on a commercial basis, or that would affect research.

6 Conclusion

This report addressed the relevance of standardization as well as the obligation to apply standards to processes. In particular, it discussed the implementation of quality systems in the laboratories of teaching and research institutions. The formation of partnerships between these laboratories and companies brings benefits for both sides: the company can resolve problems and improve its processes, while the university receives money for to purchase new equipment and to develop new technologies.

As a way to allow new partnerships and increase visibility and reputation for reliable results, while at the same time protecting their staff members, various laboratories have created quality management systems and obtained international certifications, such as according to the standards ISO 9001, ISO 14001 and OHSAS 18001.

At the end, it described the case of the Laboratory for Macromolecules and Colloids in the Petroleum Industry (LMCP). It was possible to observe that the implementation of the quality management system promoted an improvement in the services, processes and structuring of the laboratory. These include increasing customer satisfaction and reliability of results, as well as maintaining a very small number of failures. In this way, the continuous improvement process allows the laboratory to continue providing sophisticated research. This all demonstrates respect for employees and customers.

As a perspective, it is expected that other university laboratories are inspired to implement the Quality Control

System in their facilities, increasing the quality of services provided.

In the LMCP, based on all the experience acquired, it is expected to obtain the ISO 17205 certification (General requirements for the competence of testing and calibration laboratories), ISO 14001 (Environmental Management Systems certification) and ISO 45001 (Health Management System certificate and Occupational Safety).

Conflict of interest

The authors of this article claim that they do not have any type of conflict of interest.

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