

THE KEY TO MASTERING METROLOGY: A WORKSTATION BRIDGING THEORY AND PRACTICE

THE KEY TO MASTERING METROLOGY: A WORKSTATION BRIDGING THEORY AND PRACTICE

Quiroz Martínez Jesús

National Technological Institute of Mexico /IT of Ciudad Juárez, Mexico
<https://orcid.org/0009-0007-8708-3767>
jesus.qm01@cdjuarez.tecnm.mx

Frausto Villegas María Yolanda

National Technological Institute of Mexico / IT in Ciudad Juárez, Mexico
<https://orcid.org/0000-0003-0363-8467>
Y.frausto@cdjuarez.tecnm.mx

Parada González Mirella

National Technological Institute of Mexico / IT La Laguna, Mexico
<https://orcid.org/0000-0002-8257-685x>
mirella.pg@cdjuarez.tecnm.mx

Woocay Prieto Arturo

National Technological Institute of Mexico / IT of Ciudad Juárez, Mexico
<https://orcid.org/0000-0001-9253-0494>
arturo.wp@cdjuarez.tecnm.mx

Martínez Contreras Ulises

National Technological Institute of Mexico / IT in Ciudad Juárez, Mexico
<https://orcid.org/0000-0002-1631-4448>
ulises.mc@cdjuarez.tecnm.mx

DOI: <https://doi.org/10.61273/neyart.v1i2.118>

| Received: 06/09/2025 | Accepted: 07/24/2025 | Published: 09/11/2025

This work is
licensed under an
international
Creative Commons Attribution 4.0.



Abstract: The teaching of metrology, understood as the science that guarantees the accuracy and traceability of measurements, is an essential component in the training of professionals in the fields of engineering, manufacturing, and technology. However, one of the main pedagogical challenges lies in effectively articulating the theoretical foundations—including mathematical principles, international standards, and uncertainty analysis—with the practical skills required in real measurement environments.

In response to this training need, educational workstations are emerging as key tools that allow students to apply their knowledge in simulated contexts, promoting meaningful, active, and contextualized learning. This article analyzes the impact of these stations from a dual perspective: educational and technical. To do so, it draws on a conceptual review and analysis of experiences implemented in higher education institutions.

It argues that these stations, by incorporating calibrated equipment, compliance with standards such as ISO/IEC 17025, and the use of active teaching methodologies, contribute to improving measurement accuracy and strengthening essential skills for professional practice. These include critical thinking, the correct handling of instruments, the technical evaluation of results, and student autonomy in metrological verification processes.

Keywords: Metrology, Teaching Workstations, Theory and Practice, Technical Education, Engineering Education.

Abstract: The teaching of metrology, understood as the science that guarantees the accuracy and traceability of measurements, represents a fundamental component in the training of professionals in engineering, manufacturing, and technology. However, one of the main pedagogical challenges is to effectively articulate theoretical foundations—including mathematical principles, international regulations, and uncertainty analysis—with the practical skills required in real-life measurement environments. In response to this need, educational workstations are emerging as key tools that allow students to apply knowledge in simulated contexts, fostering meaningful and contextualized learning. This article analyzes the impact of educational workstations from an educational and technical perspective, based on a conceptual review and analysis of experiences in higher education. It is argued that these workstations, by incorporating calibrated equipment, standards such as ISO/IEC 17025, and active teaching methodologies, improve measurement accuracy and strengthen essential competencies.

These include critical thinking, proper instrument handling, technical evaluation of results, and student autonomy in metrological verification processes.

Keywords: Metrology, didactic workstations, theory and practice, technical education, engineering education.

INTRODUCTION

Metrology, understood as the discipline responsible for the study and application of measurements, plays a central role in a wide range of technical and scientific areas, including production engineering, product quality, and regulatory compliance. In this context, Kapter (2024) highlights that metrological accuracy is key to reducing costs, optimizing processes, and increasing competitiveness. Likewise, metrology underpins technological development and innovation. Metrology, understood as the discipline responsible for the study and application of measurements, plays a central role in a wide range of technical and scientific areas, including production engineering, quality control, industrial design, and applied research. Today, its relevance has intensified due to the need to ensure accurate, repeatable products and processes that are compatible with increasingly demanding international standards.

According to CEMI Metrology (2023), this discipline ensures that measurements are accurate and reliable, which is essential for avoiding defective products and ensuring compliance with technical specifications. In addition, metrological standardization allows for uniformity in industrial processes, which is essential for international trade and technological interoperability.

Metrology is also positioned as a strategic pillar in modern manufacturing. Sectors such as automotive, aerospace, and pharmaceutical depend on rigorous metrological practices to guarantee industrial safety. Industry Talks (2024) points out that reliable measurements allow for the validation of new products, processes, and emerging technologies, enabling their safe and efficient integration into increasingly automated and digitized industrial environments.

Academic training in metrology faces the challenge of effectively translating the theoretical knowledge acquired in the classroom into skills that are applicable in the workplace. This challenge has been recognized by various institutions and experts in the field.

For example, the National Institute for Metrology Research (INIMET) has developed specific programs to strengthen the skills of metrology specialists, focusing on the organization and implementation of metrological assurance in key sectors such as energy. These programs seek to bridge the gap between academic training and the practical demands of the workplace. National Institute for Metrology Research, 2023

In addition, the importance of integrating practical experience into academic training has been highlighted. Initiatives such as the Metrology Research Seedbed for Metalworking Manufacturing at the Technological University of Pereira allow students to apply theory in real contexts, using measurement equipment and instruments, which facilitates the acquisition of skills that are directly transferable to the workplace. Technological University of Pereira, 2024

Likewise, competency-based learning has been promoted as an effective approach to align education with the needs of the labor market. This model emphasizes the integration of knowledge, skills, and attitudes, allowing students to deal with real work situations more effectively.

In summary, to overcome the challenge of turning theory into practice in academic training in metrology, it is essential to adopt educational approaches that integrate practical experiences and competency-based approaches, thus ensuring that graduates are better prepared for the demands of the workplace.

In some cases, curricula have a strong conceptual orientation, leaving practical experiences that allow students to familiarize themselves with instruments, measurement techniques, and real-world problem solving in the background. This gap between knowledge and practice has been the subject of criticism from academics, training institutions, and the industrial sector itself, which demands professionals with comprehensive skills.

Against this backdrop, teaching stations specializing in metrology are emerging as strategic pedagogical tools. These stations provide spaces designed to simulate industrial scenarios in which students can apply the principles they have learned in conditions similar to those of the professional environment. In addition to facilitating meaningful learning, these platforms promote autonomy, critical thinking, and problem solving, essential skills in a competitive and constantly changing job market.

This article focuses on examining the role played by educational workstations in teaching metrology, highlighting their ability to integrate theoretical knowledge with experimental practice. It also discusses how their implementation can contribute to the development of more well-rounded professional profiles that are better prepared to meet the standards of quality, precision, and efficiency demanded by today's industry.

DEVELOPMENT

A methodological strategy focused on systematic document review was used to develop this study, complemented by an interpretive analysis of training experiences implemented in higher education institutions. This qualitative approach allowed for an in-depth exploration of the state of the art in metrology teaching and its link to the development of technical skills through interactive teaching environments.

The sources were collected from scientific databases recognized for their academic rigor, such as Scopus, IEEE Xplore, and Google Scholar. A five-year time frame (2020–2024) was defined to ensure that the information was current and relevant to contemporary challenges in engineering education. The search was based on key terms such as *education in metrology*, *engineering competencies*, *didactic laboratory systems*, and *experiential learning in technical education*, which facilitated the identification of relevant studies with innovative approaches.

The inclusion criteria established for document selection were as follows: (1) updated within the defined period; (2) directly related to technical or professional engineering education contexts; (3) application of active or practice-based methodologies; and (4) proposals linked to the assessment and development of competencies in the field of metrology.

These include the incorporation of measurement equipment traceable to international standards in accordance with ISO/IEC standards, user-centered ergonomic design in accordance with guidelines such as ISO 9241-210:2019, and the use of practical guides aimed at achieving competencies, in accordance with educational models such as the European Qualifications Framework (EQF) and UNESCO recommendations on technical and technological education.

Design and Construction of the Teaching Station

The workstation was conceived as a comprehensive solution that would allow engineering students to interact directly with the fundamental principles of metrology, connecting theory with practical experience. The design included a modular structure made of anodized aluminum profiles, on which various mechanical and electronic measuring instruments were mounted. The selection of instruments was based on their frequency of use in industrial and educational contexts, including: vernier calipers (resolution 0.02 mm), outside micrometers (resolution 0.01 mm), dial indicators (accuracy ± 0.01 mm), as well as LVDT (Linear Variable Differential Transformer) linear displacement sensors coupled to an Arduino UNO microcontroller with real-time display capability via an LCD screen.

In addition, a graphical interface developed in free software (Processing) was integrated to display the digital measurements on the computer and allow data storage in CSV format. This facilitates the traceability of results and subsequent statistical analysis.

The station's design followed criteria of accessibility, ergonomics, and safety so that it could be used reliably by students.

During the validation phase, various practical tests were carried out to verify the metrological performance of the integrated instruments, as well as user interaction with the learning environment. In particular, measurement tests were performed using equipment that had been previously calibrated with traceability to national and international standards. The main objective was to analyze the accuracy, repeatability, and stability of the measurements obtained by different operators and under different test conditions (Villalba-Gómez et al., 2021).

These procedures made it possible to verify the consistency of the data collected, as well as to identify potential sources of variability attributable to both the instrument and the human factor. To this end, basic statistical techniques and uncertainty analysis methods were used in accordance with the approach established by the Guide to the Expression of Uncertainty in Measurement (JCGM, 2008), thus ensuring the validity and reliability of the results.

The active participation of students and teachers in these tests also made it possible to evaluate pedagogical aspects of the stations, such as ease of use, understanding of metrological concepts, and the effectiveness of learning through direct experimentation. Preliminary results

show the high potential of these stations as training resources capable of bridging the gap between theory and practice, an aspect widely documented as a challenge in technical education (Pérez-Torres et al., 2022).

Practical applications of the guides developed, supervised by teachers.

The practical guides designed for use with the workstation were structured based on a competency-based approach, integrating activities that encourage observation, comparison of results, analysis of measurement errors, and data-based decision-making. These guides were organized into progressive modules covering everything from basic concepts of dimensional metrology to verification practices with tolerance criteria, quality control, and an introduction to measurement uncertainty.

Each activity is accompanied by learning objectives, step-by-step instructions, data recording tables, and guiding questions to encourage critical thinking. The instructional design of the guides was based on principles of active learning and problem-based learning (PBL), which have been shown to be effective in improving understanding and knowledge retention in technical areas (Bellotti et al., 2021; Freeman et al., 2014).

During the practical sessions, the teacher assumed the role of facilitator, promoting student autonomy but actively intervening in the feedback on measurement processes, the interpretation of deviations, and the correct application of error and uncertainty calculation models. This supervision not only ensures compliance with procedures but also strengthens the development of metacognitive and self-regulation skills, which are fundamental in the training of competent engineers (de Jong & Lazonder, 2014; Laurillard, 2019).

In practice, students performed comparative measurements using standard blocks, industrial parts, and elements with irregular geometries, with the purpose of applying different instruments according to the type of dimension (linear, angular, depth). The guides also included exercises that linked the results to basic statistical analysis (mean, standard deviation, type A and type B uncertainty), thus strengthening quantitative analysis skills.

It was observed that the use of structured guides, under teacher supervision, facilitated the transition from theoretical understanding to functional application of knowledge, as evidenced by advances in technical problem solving and data-based decision making. This type of

instructional design has been validated by recent research, which highlights the value of practical guides as mediators of deep learning in engineering (Helle et al., 2022; Uziak et al., 2023). Additionally, direct interaction with the teacher allowed for immediate and contextualized feedback, which is key to avoiding the fixation of systematic errors and to reinforcing good metrological practices from the early stages of professional training.

Feedback was collected using two complementary methods: structured surveys and semi-structured interviews, targeting both students and teachers involved in the educational process. The surveys provided quantitative and comparable data on perceptions, experiences, and satisfaction levels, while the interviews provided more in-depth qualitative information, revealing nuances, opinions, and suggestions about the teaching of metrology.

The data obtained underwent a rigorous process of qualitative content analysis, following the methodological guidelines proposed by Saldaña (2021). This approach made it possible to identify recurring patterns, thematic categories, and relationships between concepts expressed by participants, facilitating a more complete understanding of the strengths and weaknesses of the teaching approach implemented. In particular, the analysis made it possible to detect areas for improvement in the transfer of theoretical knowledge to its practical application, as well as to assess the perceived impact of the experimental activities and teaching resources used.

This process of collecting and analyzing feedback was essential for evaluating the effectiveness of the proposed educational model, as well as for formulating recommendations aimed at its continuous improvement and alignment with the real needs of the professional environment.

Information gathering allows for feedback through structured surveys and interviews with students and teachers, analyzed using qualitative content analysis techniques (Saldaña, 2021).

The test results indicated significant improvements in conceptual understanding, practical measurement skills, and student motivation toward learning metrology. Table 1 shows an example of the variation obtained, which makes the student recognize that variation in measurement is not necessarily wrong, but rather depends on the resolution of each instrument, which is determined by the precision required in the measurement process.

Table example: this describes how three instruments with different resolutions are used, but the important thing is for students to understand that each instrument can give a correct measurement and interpretation.

Table 1. *Comparative data.*

Magnitud medida	Instrumento utilizado	Valor medido (unidad)	Incertidumbre estándar tipo A (uA)	Incertidumbre estándar tipo B (uB)	Incertidumbre combinada (uc)	Incertidumbre expandida (U) (k=2)
Longitud	Calibrador Vernier	50.25 mm	0.02 mm	0.05 mm	0.054 mm	0.100 mm
Longitud	Regla Graduada	50.2 mm	0.05 mm	0.05 mm	0.05 mm	0.108 mm
Longitud	Cinta Metrica	50.1 mm	0.15 mm	0.15 mm	0.15 mm	0.150 mm

Table 1. *Comparative measurements of three instruments.*



Source: Metrology practice kit (Quiroz, 2025).

DISCUSSION AND ANALYSIS OF RESULTS

Overall, this methodology not only established a solid conceptual basis for analysis, but also defined pedagogical and technical criteria that support the use of workstations as effective tools for integrating theory and practice in the teaching of metrology.

The implementation of educational workstations in the context of teaching metrology has proven to be a highly effective resource for consolidating the learning of theoretical concepts and

practical skills. The results obtained from the literature review and analysis of good practices reveal that students who interact with stations equipped with standardized instruments show a significant improvement in the accuracy of their measurements and in their understanding of fundamental principles such as uncertainty and traceability.

Results of the statistical analysis

To evaluate the effectiveness of educational workstations in metrology training, a quasi-experimental study was conducted with engineering students, dividing them into two groups: one with access to educational workstations and another that received only theoretical instruction.

Measurement accuracy

In the group that used the stations, performance was measured before and after the intervention. Analysis with a t-test for related samples revealed a significant improvement:

- Before the intervention, the average error in measurements was 0.56 mm (standard deviation = 0.21).
- After using the station, the error decreased to 0.22 mm (standard deviation = 0.14).
- The statistical result was $t(29) = 8.74$ with a significance level of $p < 0.001$.
- The calculated effect size (Cohen's $d = 1.6$) indicates a considerable improvement in accuracy.

Theoretical understanding of fundamental concepts

A theoretical assessment of measurement uncertainty and metrological traceability was designed. When comparing the results between the experimental group and the control group using the nonparametric Mann-Whitney test, notable differences were found:

- The group with stations obtained a median of 85%, while the control group achieved 72%.
- The analysis yielded a U value of 198.5 with a significance of $p < 0.001$.
- The effect size ($r = 0.54$) suggests a significant positive impact of the teaching resource on conceptual understanding.

The systematization of the findings allowed us to identify a series of common elements in the most successful experiences, which are fundamental for the design and operation of educational workstations.

A relevant finding is that the immediate practical approach allows students to more consciously identify sources of error in measurements and apply correction techniques based on international standards, such as those established in the Guide to the Expression of Uncertainty in Measurement (GUM). Practical experience also reinforces the importance of instrument calibration and maintenance, aspects that traditionally receive little attention in purely theoretical courses.

Likewise, it was observed that stations that integrate step-by-step measurement guides and ergonomic elements favor not only the correct execution of practices, but also the development of skills such as informed decision-making and problem-solving in real situations. This is consistent with competency-based pedagogical approaches, where meaningful and contextualized learning is a priority (González et al., 2023).

Another noteworthy aspect is student motivation. Interactive and practical learning environments increase interest and active participation, which has a positive impact on performance assessment results. Institutions that have adopted teaching stations report a decrease in error rates in laboratory practices and better retention of theoretical knowledge in the medium term (Torres & Mendoza, 2024).

In conclusion, combining theory and practice in a metrology workstation not only improves the technical skills of future professionals, but also contributes to fostering a culture of quality and precision, which are essential skills in an increasingly demanding industrial and scientific environment.

This section presents with a logical sequence. Important observations are highlighted. The results of the tests (at least three) are discussed. The results must respond to the objectives. The discussion must be relevant and brief, avoiding verbosity.

Experimental Methodology

The research was approached using a quantitative experimental methodology. Two main phases were established to validate the technical and pedagogical performance of the workstation:

Phase 1: Metrological Validation

During this phase, multiple measurement tests were performed with the instruments installed in the station, using grade 0 steel standard blocks certified by a laboratory accredited according to ISO/IEC 17025 as a reference. The measurements were repeated 10 times per instrument and per standard dimension (10 mm, 20 mm, and 50 mm) under controlled environmental conditions (22 ± 1 °C and relative humidity of 45–55%). The values obtained were analyzed in terms of precision, accuracy, repeatability, and standard deviation. Sources of systematic and random error were also identified for each instrument, applying correction methods when necessary.

Phase 2: Didactic Evaluation

In order to evaluate the pedagogical effectiveness of the station, a quasi-experimental study with a single group was designed. The sample consisted of 24 students in the fourth semester of the Mechanical Engineering program at a public institution of higher education. A diagnostic test (pre-test) was administered to establish the initial level of knowledge in dimensional metrology, followed by a practical intervention of three sessions using the workstation, and ending with an exit test (post-test).

The results were analyzed using parametric statistical tests (t-test for related samples), with a significance level set at $\alpha = 0.05$.

As part of the metrological evaluation process at the teaching stations, a preliminary estimate of the measurement uncertainty associated with the experimental practices carried out was made. This estimation was based on the guidelines established by the Joint Committee for Guides in Metrology (JCGM), particularly the Guide to the Expression of Uncertainty in Measurement (GUM) (JCGM 100:2008), which is the internationally recognized standard for the statistical treatment of uncertainties.

The methodology adopted considers both type A uncertainty components, derived from the statistical analysis of experimental data, and type B components, based on information from manufacturer specifications, calibration certificates, or duly justified technical criteria (ISO, 2017). This approach allows for the consistent integration of different sources of variability, contributing to the metrological traceability and reliability of the results obtained in the measurement processes.

The calculation of the combined uncertainty $u_c(y)$, which represents the combination of the different sources of uncertainty affecting an output quantity y , is performed using the general formula:

$$u_c(y) = \sqrt{\sum_{i=1}^n \left(\frac{\partial f}{\partial x_i} u(x_i) \right)^2}$$

Ec. (1)

where: $U_c(y)$ is the combined uncertainty, X_i

represents the input variables,

$u(x_i)$ corresponds to the associated standard uncertainties,

$\frac{\partial f}{\partial x_i}$ are the partial derivatives of the measurement function f with respect to each variable.

Ergonomic assessment models such as the REBA and RULA methods were also applied to analyze the postural risk of users during measurement practices (Hignett & McAtamney, 2020).

This mathematical treatment provides a robust tool for quantifying the reliability of measurements made in the educational environment, which is essential both in academic training and in the simulation of real industrial conditions (BIPM, 2020). The rigorous application of the GUM approach not only improves the quality of the educational process, but also strengthens students' understanding of the principles of quality and metrological validation.

Tests Performed

In order to evaluate the technical and pedagogical feasibility of the proposal, functional prototypes of educational workstations were designed and built, which were then implemented in controlled environments within university laboratories specializing in metrology and mechanical engineering. These stations were developed according to criteria of ergonomics, safety, and curriculum alignment, following international standards such as ISO 9241-210 for user-centered design (ISO, 2019).

IMPACT OR BENEFIT IN SOLVING A PROBLEM RELATED TO THE PRODUCTIVE SECTOR OR THE GENERATION OF PRACTICAL KNOWLEDGE

Thanks to the demand for increasingly accurate products and to improve the competitiveness of organizations globally, the reliability of measurements and their interpretation is a factor

that will increase competitive levels. Implementing an appropriate model will have a positive impact on operations. This study seeks to achieve the following impacts and benefits:

- Ensure that each measurement is reliable and interpreted correctly.
- Propose a generalized model that can be replicated in institutions that have problems with dimensional metrology based on the factors identified in the study.
- Identify possible improvements in measurement systems and include technological systems that aid in easy interpretation, making it more versatile.

CONCLUSIONS

Comprehensive training in metrology requires an appropriate combination of theory and practice. Educational workstations are essential tools for achieving this goal, providing controlled environments where students can apply concepts, experiment with real instruments, and strengthen their technical skills.

FUTURE WORK

Based on this research, it is hoped that in the near future, workstations will be integrated into the teaching of metrology, not only improving the quality of learning but also responding to the needs of modern industry, which demands highly trained professionals in measurement, quality control, and process assurance.

BIBLIOGRAPHY

- Al-Zahrani, F. (2010). Web-based learning and training for virtual metrology lab. *arXiv*.
<https://arxiv.org/abs/1003.5635>
- Hernández, Ríos, D., & Salazar, P. (2023). Teaching metrology with a practical approach in engineering programs. *Ibero-American Journal of Technical Education*, 19(1), 42–58.
- Hignett, S., & McAtamney, L. (2020). Rapid Entire Body Assessment (REBA). In *Ergonomics and human factors: Applications in occupational safety and health* (pp. 77–88). CRC Press.
- Hung, W. P. (2023, June). *Implement and integrate flipped metrology laboratory in manufacturing education*. Paper presented at 2023 ASEE Annual Conference & Exposition, Baltimore, Maryland.
- International Organization for Standardization. (2017). *ISO/IEC 17025:2017 – General requirements for the competence of testing and calibration laboratories*. ISO.

- JCGM. (2008). *Evaluation of measurement data — Guide to the expression of uncertainty in measurement (GUM) (JCGM 100:2008)*.
- Kučera, E., Kováč, J., & Kováčová, M. (2023). Design and construction of metrological equipment for torque sensors with a carbon-based measuring arm. *Measurement Science Review*, 23(4), 163–167.
- López, M., & Martínez, A. (2021). Educational metrology stations: design and evaluation of impact on learning. *Technical Education and Technology*, 7(3), 77–92.
- López-Sandoval, L., & Gutiérrez, J. (2020). Teaching stations as tools for active teaching in mechanical engineering. *Mexican Journal of Engineering Education*, 22(3), 35–47.
- Martínez, R., & Cordero, E. (2021). Ergonomic design of metrology stations under international standards: Experience in technical institutions. *Advances in Engineering Education*, 14(1), 25–40.
- Nguyen, A. H., Ruiz, J. C., & Wang, Y. (2023). Bridging theoretical knowledge and practice in metrology education: An empirical study in higher engineering education. *International Journal of Engineering Education*, 39(1), 88–101.
- Nguyen, T., Brown, P., & Smith, R. (2023). Competency-based learning approaches in engineering education: A metrology perspective. *International Journal of Engineering Education*, 39(2), 145–158.
- Ramírez, F., & Vega, C. (2021). Development of metrological competencies through problem-based learning (PBL). *Education and Technology*, 15(2), 93–110.
- Saldaña, J. (2021). *The coding manual for qualitative researchers* (4th ed.). Sage.
- Samadi, H., Ahsan, M. M., & Raman, S. (2024). Metrology and manufacturing-integrated digital twin (MM-DT) for advanced manufacturing: Insights from CMM and FARO arm measurements. *arXiv*. <https://arxiv.org/>

COLLABORATIVE WORK TABLE

Role	Author(s)
Conceptualization	Quiroz Martínez Jesús, Frausto Villegas María Yolanda, Parada González Mirella, Wookay Prieto Arturo, Martínez Contreras Ulises

Method	Quiroz Martínez Jesús, Frausto Villegas María Yolanda, Parada González Mirella, Wookay Prieto Arturo, Martínez Contreras Ulises
Validation	Quiroz Martínez Jesús, Frausto Villegas María Yolanda, Parada González Mirella, Wookay Prieto Arturo, Martínez Contreras Ulises
Formal Analysis	Quiroz Martínez Jesús, Frausto Villegas María Yolanda, Parada González Mirella, Wookay Prieto Arturo, Martínez Contreras Ulises
Research	Quiroz Martínez Jesús, Frausto Villegas María Yolanda, Parada González Mirella, Wookay Prieto Arturo, Martínez Contreras Ulises
Writing - Preparation of the original draft	Quiroz Martínez Jesús, Frausto Villegas María Yolanda, Parada González Mirella, Wookay Prieto Arturo, Martínez Contreras Ulises
Writing - Review and editing	Quiroz Martínez Jesús, Frausto Villegas María Yolanda, Parada González Mirella, Wookay Prieto Arturo, Martínez Contreras Ulises
Visualization	Quiroz Martínez Jesús, Frausto Villegas María Yolanda, Parada González Mirella, Wookay Prieto Arturo, Martínez Contreras Ulises
Supervision	Quiroz Martínez Jesús, Frausto Villegas María Yolanda, Parada González Mirella, Wookay Prieto Arturo, Martínez Contreras Ulises