Research Paper

Enhancing the Role of ISO/IEC 17025:2017 Accredited Laboratories in Supporting *Tri Dharma Perguruan Tinggi* at Geological Engineering Department of UPN "Veteran" Yogyakarta

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Abstract

Laboratories play a crucial role in supporting the *Tri Dharma Perguruan Tinggi*, education, research, and community service in Indonesian higher education institutions. Accreditation under ISO/IEC 17025:2017 provides international recognition of laboratory competence, impartiality, and operational consistency. However, accreditation status alone does not automatically ensure optimal utilization of laboratory resources. This study examines the case of two accredited laboratories, the Optical Mineralogy and Petrology Laboratory and the Micropaleontology Laboratory at the Department of Geological Engineering, Universitas Pembangunan Nasional "Veteran" Yogyakarta. Using a mixed-methods approach, the research relied on primary data from direct observations, training and certification records, and internal quality audits, complemented by secondary documentation, including standard operating procedures, calibration certificates, and utilization reports. Data were analyzed through thematic analysis, descriptive statistics, and gap and SWOT frameworks to evaluate laboratory performance. Findings reveal that accreditation has strengthened organizational structures, enhanced staff competencies, and improved technical reliability. Nevertheless, several challenges remain, including overlapping responsibilities between quality and administrative management, the need for regular refresher training, inconsistent calibration schedules, and overly complex organizational structures. To address these issues, the study proposes strategies such as targeted recruitment, annual calibration programs with digital monitoring, organizational streamlining, and enhanced internal audits. The study concludes that ISO/IEC 17025:2017 accreditation, when combined with systematic optimization, can significantly enhance the role of laboratories in higher education by ensuring the credibility of teaching, research, and community services. Further research should include comparative and longitudinal studies, as well as exploration of digital quality management systems and industry partnerships to maximize the long-term impact of accredited laboratories.

Keywords *accredited laboratories, ISO/IEC 17025:2017, Tri Dharma Perguruan Tinggi, quality assurance,*

INTRODUCTION

Laboratories serve as one of the essential infrastructures in higher education, functioning not only as facilities for teaching and learning but also as hubs for research and community engagement. Within the framework of *Tri Dharma Perguruan Tinggi* (education, research, and community service), laboratories provide practical learning opportunities, generate scientific data for innovation, and deliver technical services to society. In the current era of globalization, the demand for reliable and competent laboratories has grown substantially, especially as higher education institutions are expected to meet international standards of quality and competitiveness.

To address this challenge, the application of international quality assurance systems, such as ISO/IEC 17025:2017, has become increasingly important. This standard specifies the general requirements for the competence, impartiality, and consistent operation of testing and calibration laboratories. Laboratories accredited under ISO/IEC 17025:2017 are recognized globally for their technical reliability and quality management systems, ensuring that the analytical results they produce are valid, traceable, and trusted by both academic and industrial stakeholders.

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While accreditation demonstrates compliance with global standards, it does not automatically ensure the optimal utilization of laboratory resources. Accredited laboratories may still face constraints in maximizing their contribution to the three pillars of higher education. At the Department of Geological Engineering, Faculty of Mineral and Energy Technology, Universitas Pembangunan Nasional "Veteran" Yogyakarta (UPNVY), two laboratories (the Optical Mineralogy and Petrology Laboratory and the Micropaleontology Laboratory) have achieved ISO/IEC 17025:2017 accreditation. However, several issues remain. Challenges include limited human resources, where some key positions, such as quality managers and administrative staff, are still overlapping or vacant; the need for continuous training and refreshment to ensure staff competence; the necessity of periodic equipment calibration to maintain accuracy; and the need to streamline organizational structures to avoid overlapping functions. Without addressing these gaps, the full potential of accreditation in supporting education, research, and community service cannot be realized.

This study is significant because it provides a case study from Indonesia, focusing on how ISO/IEC 17025:2017-accredited laboratories can be leveraged beyond their accreditation status to achieve broader institutional goals. The Geological Engineering Department at UPN "Veteran" Yogyakarta offers a relevant context, as it integrates laboratory facilities into the curriculum, research projects, and community service programs related to geological sciences. The findings are expected to contribute not only to the institutional development of UPNVY but also to the broader discourse on laboratory optimization in higher education institutions in developing countries. By identifying both the supporting factors and the barriers, this study adds empirical evidence to the limited literature on laboratory management within the context of ISO-based accreditation in academia.

The objectives of this research are fourfold. First, to analyze the current level of utilization of ISO/IEC 17025:2017 accredited laboratories in supporting education, research, and community service at the Department of Geological Engineering, UPNVY. Second, to identify the key enabling factors that enhance laboratory optimization. Third, to highlight the constraints that hinder effective implementation, whether in terms of human resources, equipment, or management systems. Finally, to formulate strategic recommendations for maximizing the role of accredited laboratories in strengthening the Tri Dharma Perguruan Tinggi and enhancing institutional competitiveness at both the national and international levels.

LITERATURE REVIEW

ISO/IEC 17025:2017 Standard

ISO/IEC 17025:2017 is the international standard that specifies the general requirements for the competence, impartiality, and consistent operation of testing and calibration laboratories. It serves as a globally recognized benchmark, ensuring that laboratories produce valid and reliable data that can be accepted across international borders. The standard not only guides laboratories in maintaining the quality of testing and calibration but also assures their competence for global recognition (ISO, 2017). Its implementation strengthens public trust in laboratory results and demonstrates best practices in laboratory management.

In the context of higher education, the adoption of ISO/IEC 17025:2017 aligns with the global demand for quality assurance in scientific outputs. Accredited laboratories are required to implement rigorous quality management systems, guarantee traceability of measurements, and maintain impartiality in their operations. Consequently, accreditation under this standard represents not only a technical achievement but also a strategic asset for universities seeking to enhance their credibility and competitiveness in the international academic community.

Quality Assurance in Higher Education

Quality assurance in Indonesian higher education is governed by the Standar Nasional Pendidikan Tinggi (SNPT) and implemented through both internal quality assurance systems (Sistem Penjaminan Mutu Internal or SPMI) and external accreditation. According to the latest regulation, Permendikbudristek No. 53 (2023), universities are mandated to establish, implement, evaluate, control, and continuously improve their quality standards as part of an internal quality improvement cycle.

While international frameworks, such as ISO 21001:2018, are increasingly applied in educational institutions to enhance service quality and stakeholder satisfaction, ISO/IEC 17025:2017 remains the primary reference standard for testing and calibration laboratories. Integrating these standards ensures not only compliance with national educational quality requirements but also alignment with global best practices. Within this framework, accredited laboratories contribute significantly to institutional quality assurance by providing valid scientific outputs and supporting evidence-based decision-making processes (Suratmanto & Emanuel, 2024; Sutrisno, 2018)

The Tri Dharma of Higher Education and the Role of Laboratories

The Tri Dharma Perguruan Tinggi—education, research, and community service, constitutes the core mission of higher education institutions in Indonesia. Laboratories play a central role in realizing these three pillars. In education, laboratories enable students to gain empirical and hands-on experience, reinforcing theoretical knowledge with practical applications. As noted by Sutrisno (2018), laboratory-based learning improves analytical skills, technical competencies, and conceptual understanding.

In research, well-equipped laboratories facilitate the verification of theories, exploration of new ideas, and production of credible data for scientific publications. For instance, the High Voltage Engineering Laboratory at Universitas Gadjah Mada (UGM) emphasizes its dual function in teaching and advanced research, such as high-voltage asset management and insulation failure studies (UGM, 2025). Furthermore, in community service, laboratories provide technical services such as soil, rock, or water testing, contributing directly to public infrastructure planning, disaster mitigation, and environmental management

Accredited laboratories, as defined by ISO/IEC 17025:2017, further enhance the quality of these functions. By applying standardized procedures and ensuring the validity of test results, such laboratories can support high-quality education, generate credible scientific outputs for research, and deliver reliable technical services to communities and industries. Therefore, optimizing the utilization of accredited laboratories at the Department of Geological Engineering, UPN "Veteran" Yogyakarta, is expected to amplify their contributions to the Tri Dharma and strengthen the institution's role in advancing science, technology, and societal development.

RESEARCH METHOD

This research employed an applied mixed-methods design with a descriptive-analytical approach. A mixed-methods strategy was chosen to capture both quantitative measures of laboratory performance and qualitative insights into management practices, thereby providing a comprehensive understanding of the issues (Aisyah et al., 2024). Such an approach enables the triangulation of data – the convergence of statistical trends and thematic observations – to enhance the validity of findings (Johnson & Onwuegbuzie, 2004). In the context of evaluating laboratory quality systems, combining qualitative and quantitative methods is particularly useful because it enables the study to address both technical compliance metrics and human and organizational factors (Khodabocus & Balgobin, 2011). The research was conducted at the Department of

Geological Engineering, UPN "Veteran" Yogyakarta, focusing on two ISO/IEC 17025:2017 accredited laboratories (the Optical Mineralogy & Petrology Lab and the Micropaleontology Lab) as the unit of analysis. These labs were selected as they provide critical services for teaching, research, and community projects, offering a pertinent case to examine how accreditation influences performance in a higher education setting. Data collection relied on primary sources, including direct observations of laboratory activities, training and certification records, post-test evaluations, and internal quality audits. Secondary sources, including standard operating procedures, calibration certificates, and laboratory utilization records, complemented these. Together, these data provided a comprehensive overview of how the laboratories implement ISO/IEC 17025:2017 and contribute to academic and community functions.

Data analysis was carried out through qualitative thematic analysis of audit results and observation notes, descriptive statistics of training evaluations, and both gap and SWOT analyses to identify discrepancies between expected and actual practices. This methodological approach enabled the formulation of strategic recommendations for optimizing human resources, equipment management, and system implementation within the accredited laboratories.

FINDINGS AND DISCUSSION

Evaluation of Existing Conditions

Human Resources (HR)

The evaluation of human resources reveals that both the Optical Mineralogy and Petrology Laboratory and the Micropaleontology Laboratory have relatively complete organizational structures, consisting of coordinators, technical managers, technicians, quality managers, supervisors, and administrative staff. Most personnel have participated in essential ISO/IEC 17025:2017 training programs, including courses on measurement uncertainty, proficiency testing, and internal auditing. This indicates a strong foundational capacity to maintain compliance with international quality standards.

However, challenges remain in the Micropaleontology Laboratory, where quality management and administrative responsibilities are still concentrated in overlapping roles. This dual assignment raises potential risks of conflict of interest, uneven workload distribution, and incomplete documentation. Moreover, despite the staff's initial training, there is a pressing need for continuous professional development, particularly through refresher and advanced training on best practices in documentation, risk management, and internal auditing. Without systematic staff reinforcement, the laboratories risk stagnation in their capacity to adapt to evolving quality standards.

Equipment

The evaluation of equipment reveals that major instruments, including the Olympus BX-53 and Meiji Tecno MT9300 polarizing microscopes, binocular microscopes, ovens, and sample preparation tools, are in good operational condition. Several instruments underwent calibration in 2023, demonstrating adherence to ISO/IEC 17025 technical requirements.

Nevertheless, the analysis indicates that consistent and periodic calibration remains a challenge. All accredited laboratories are required to maintain calibration schedules every one to two years to ensure measurement accuracy. Failure to meet these requirements may compromise the validity of test results, directly affecting the credibility of laboratory outputs used for teaching, research, and community service. Thus, establishing an annual calibration system, complemented by digital monitoring and record-keeping, is critical to sustaining compliance and maintaining international recognition.

System and ISO/IEC 17025 Implementation

The laboratories possess comprehensive quality management documents, including quality manuals, standard operating procedures, and work instructions. Internal quality audits have been conducted, though the consistency and systematic follow-up of findings remain areas for improvement. Observations also reveal that the organizational structure of the laboratories is overly layered, leading to potential overlaps in responsibilities and reduced efficiency.

To address these issues, restructuring is recommended to simplify reporting lines and clarify roles, thereby streamlining quality management processes. Furthermore, strengthening internal audits and conducting regular management reviews will enhance accountability, promote continuous improvement, and increase readiness for external assessments. These steps are essential for transforming ISO/IEC 17025 accreditation from a compliance-driven status into a dynamic instrument for institutional excellence.

SWOT Analysis

The evaluation of ISO/IEC 17025:2017 accredited laboratories highlights both the strengths and challenges that influence their contributions to higher education. A SWOT analysis was conducted to systematically identify discrepancies between the expected implementation of the standard and the actual practices observed.

- Strengths**:**

  The laboratories benefit from well-established accreditation under ISO/IEC 17025:2017, which serves as a strong institutional credential. Core instruments, including polarizing microscopes, ovens, and sample preparation tools, are in good condition and have undergone recent calibration, ensuring technical reliability. Additionally, most laboratory staff have received training in key areas, such as measurement uncertainty, proficiency testing, and internal auditing, indicating a solid foundation for maintaining compliance.

- Weaknesses**:**

  Despite these strengths, several weaknesses hinder optimal utilization. In the Micropaleontology Laboratory, overlapping roles in quality management and administration create potential conflicts of interest and administrative inefficiencies. Furthermore, refresher training has not been conducted regularly, leading to uneven levels of staff competence. In terms of equipment, calibration is not performed systematically on an annual basis, which creates risks to the validity and credibility of test results. Organizational structures also appear overly layered, which may reduce operational efficiency and complicate decision-making processes.

- Opportunities:

  The laboratories have significant opportunities to enhance their role in supporting the *Tri Dharma Perguruan Tinggi*. The growing demand for international-standard testing services in higher education and industry presents an opportunity for broader collaborations and external funding. The integration of digital monitoring systems for equipment calibration and documentation can improve compliance, transparency, and efficiency. Moreover, continuous training programs and partnerships with external accreditation bodies provide opportunities to strengthen human resources and align with global best practices.

- Threats**:**

  Several external factors pose threats to sustainability. Financial constraints may limit the frequency of calibration and advanced training programs, which are essential for maintaining accreditation. Additionally, increasing global competition among academic laboratories raises the pressure to improve performance and efficiency continuously. If gaps in human resources and documentation persist, the risk of non-conformance during external audits may undermine the credibility of the accreditation.

Discussion

The evaluation of existing conditions and the subsequent SWOT analysis provide critical insights into the actual implementation of ISO/IEC 17025:2017 within the Optical Mineralogy and Petrology Laboratory and the Micropaleontology Laboratory at the Department of Geological Engineering, UPN "Veteran" Yogyakarta. While accreditation establishes a formal recognition of competence, the findings show that optimal utilization of the laboratories requires systematic reinforcement across human resources, equipment management, and organizational systems.

From the perspective of human resources, the presence of trained personnel who have participated in courses on measurement uncertainty, proficiency testing, and internal auditing represents a notable strength. However, the overlapping of roles, particularly in quality management and administration demonstrates a significant weakness. This discrepancy between the expected clear division of responsibilities under ISO/IEC 17025 and the actual practice creates risks of inefficiency and conflicts of interest. The situation indicates the need for targeted recruitment and periodic refresher training to ensure balanced workloads and sustained staff competence.

In terms of equipment, the laboratories maintain essential instruments in good condition, supported by recent calibration efforts. This reflects compliance with the technical requirements of ISO/IEC 17025. Nevertheless, the evaluation highlights that calibration schedules are not consistently enforced on an annual basis, resulting in gaps between the expected systematic calibration and actual implementation. This weakness undermines the credibility of test results and must be addressed through a structured calibration program, ideally supported by digital monitoring systems to enhance reliability and documentation.

About the system and organizational structure, the laboratories have developed comprehensive quality management documentation, including quality manuals, SOPs, and internal audit records. These documents demonstrate alignment with the expectations of ISO/IEC 17025. However, discrepancies emerge in practice: internal audits are not always followed up on systematically, and the organizational structure appears overly complex and layered. This reduces efficiency and dilutes accountability compared to the streamlined and responsive system envisioned in the accreditation framework. Restructuring the organization and enhancing the cycle of internal audits and management reviews would help bridge this gap and strengthen long-term compliance.

The SWOT analysis further emphasizes the dynamic interplay between internal conditions and external environments. The laboratories' accreditation, technical competence, and training programs constitute their strengths, while overlapping roles, limited refresher training, and inconsistent calibration represent their weaknesses. At the same time, opportunities exist to leverage accreditation for broader collaborations, external funding, and digital transformation in laboratory management. Conversely, threats such as financial constraints, global competition, and the risk of non-conformance during external audits highlight the urgency of addressing internal weaknesses.

Taken together, the discussion confirms that accreditation is only the starting point. Without continuous improvement, laboratories risk falling short of their potential to advance education, research, and community service. To align actual practices with the expectations of ISO/IEC 17025, the Department of Geological Engineering must prioritize staff reinforcement, enforce strict calibration cycles, streamline organizational structures, and institutionalize internal audits as a culture of quality. By doing so, the laboratories will not only maintain compliance but also transform accreditation into a driver of institutional excellence, academic competitiveness, and societal impact.

CONCLUSIONS

This study confirms that ISO/IEC 17025:2017 accreditation provides a solid foundation for strengthening the role of academic laboratories in advancing education, research, and community service. The case of the Optical Mineralogy and Petrology Laboratory and the Micropaleontology Laboratory at the Department of Geological Engineering, UPN "Veteran" Yogyakarta, illustrates both the benefits and the limitations of accreditation. Accreditation has improved organizational recognition, ensured technical reliability using calibrated instruments, and enhanced staff competence through training in measurement uncertainty, internal audits, and quality management practices. These strengths demonstrate the laboratories' readiness to deliver valid and credible data for academic and societal purposes.

LIMITATIONS & FURTHER RESEARCH

This study confirms that ISO/IEC 17025:2017 accreditation provides a solid foundation for strengthening the role of academic laboratories in advancing education, research, and community service. The case of the Optical Mineralogy and Petrology Laboratory and the Micropaleontology Laboratory at the Department of Geological Engineering, UPN "Veteran" Yogyakarta, illustrates both the benefits and the limitations of accreditation.

Accreditation has improved organizational recognition, ensured technical reliability through the use of calibrated instruments, and enhanced staff competence through training in measurement uncertainty, internal audits, and quality management practices. These strengths demonstrate the laboratories' readiness to deliver valid and credible data for academic and societal purposes.

On the other hand, discrepancies between expected standards and actual practices remain evident. Overlapping roles in quality and administrative management, the absence of systematic refresher training, inconsistent calibration schedules, and an overly layered organizational structure reduce the efficiency and sustainability of laboratory operations. These weaknesses highlight that accreditation alone does not guarantee optimal utilization.

To bridge these gaps, strategic efforts must focus on reinforcing human resources through targeted recruitment and continuous training, implementing structured annual calibration supported by digital monitoring, and streamlining organizational systems to strengthen accountability. By aligning actual practices with ISO/IEC 17025 requirements, the laboratories can transform accreditation into a sustainable mechanism for institutional excellence, thereby enhancing their contribution to the Tri Dharma Perguruan Tinggi and positioning UPN "Veteran" Yogyakarta as a more competitive academic institution in the global arena.

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