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Comparative SERVQUAL analysis of academic service satisfaction among building and mechanical engineering education students for quality assurance and SDG 4

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ABSTRACT

Objective: *To evaluate baseline student satisfaction, compare service quality between two "Accredited Excellent" vocational engineering programs-S1 Building Engineering Education (PTB) and S1 Mechanical Engineering Education (PTM)-and diagnose operational bottlenecks to align empirical findings with institutional quality assurance and global educational standards.* ***Method:*** *A quantitative comparative-descriptive survey design was conducted with a stratified random sample of N = 422 undergraduate students (PTB N1 = 215 and PTM N2 = 207). Data were collected using a 23-indicator SERVQUAL instrument on a 4-point Likert scale and analyzed using descriptive statistics (Mean, Standard Deviation, Respondent Achievement Degree/TCR), independent-samples t-tests (a = 0.05), and Cohen's d effect size estimations.* ***Results****: Although overall satisfaction reached a "Satisfied" baseline (TCR = 75.47%), inferential testing revealed a statistically significant disparity (p = 0.0429) favoring PTB over PTM. Granular item analysis isolated critical operational bottlenecks in laboratory equipment adequacy (P18), general campus facility accessibility (P23), and administrative responsiveness in facility loan procedures (P16).* ***Novelty:*** *The research shows that top-tier accreditation does not guarantee uniform program-level service delivery, offering a pioneering framework that directly integrates granular SERVQUAL diagnostics into the institutional Internal Quality Assurance System (SPMI-PPEPP cycle) and United Nations Sustainable Development Goal 4 (Targets 4. a and 4.4).*

INTRODUCTION

In the modern global higher education landscape, institutional success is increasingly defined by the capacity to deliver high-quality, student-centered academic and administrative services. In engineering and vocational higher education, service quality extends beyond traditional classroom instruction to include complex laboratory infrastructure, technical equipment availability, administrative efficiency, and holistic student support systems. Because engineering education relies heavily on experiential and hands-on learning, student perceptions of service quality serve as a critical barometer for institutional effectiveness, student retention, and graduate competency (Tight, 2020). Consequently, higher education institutions worldwide face increasing pressure to systematically monitor, evaluate, and enhance service delivery to meet modern accreditation benchmarks and industry demands (Sallis, 2014).

To evaluate service quality in educational settings, the SERVQUAL framework originally developed by Zeithaml et al. (1990) remains one of the most widely adopted diagnostic tools. The framework evaluates service quality across five core dimensions: Tangibles, Assurance, Responsiveness, Empathy, and Reliability. Scholarly literature in higher education management has extensively utilized SERVQUAL to identify gaps between student expectations and perceptions (Yousapronpaiboon, 2014), as well as to evaluate service quality in broader higher education ecosystems (Bo, 2025; Tan & Kek,

2004). Prior empirical studies have established that tangible assets such as state-of-the-art laboratory equipment, modern workshop infrastructure, and accessible digital systems strongly influence student satisfaction in technical disciplines, particularly within technical and vocational education and training environments (Azeem et al., 2018). Furthermore, research demonstrates that responsiveness in administrative workflows, such as equipment borrowing and scholarship processing, directly impacts students' academic productivity and overall institutional trust (Ariyanto et al., 2026; Park et al., 2022).

Despite the abundance of SERVQUAL literature in higher education, existing research exhibits a significant analytical blind spot. Most published studies treat universities or faculties as uniform, homogeneous entities, generating aggregate satisfaction scores that obscure micro-level operational disparities between individual study programs (Campos et al., 2017; Imane et al., 2026). Furthermore, while previous literature frequently diagnoses service gaps, it rarely connects empirical quantitative findings to internal institutional quality assurance systems or global development goals (Dugenio-Nadela et al., 2023). Specifically, there is a distinct lack of empirical literature examining how program-level service disparities persist within faculties that hold top-tier institutional accreditation (Hazelkorn, 2011; Kayyali, 2024), and how SERVQUAL diagnostics can be operationally embedded into formal continuous improvement cycles (Kayyali, 2023; Mireku & Bervell, 2024; OECD, 2021) like Indonesia's Internal Quality Assurance System (Sistem Penjaminan Mutu Internal - SPMI) and the United Nations Sustainable Development Goal 4 (SDG 4: Quality Education) (Boeren, 2019).

This research gap creates a compelling managerial and academic paradox at the Faculty of Engineering, Universitas Negeri Surabaya (UNESA). Both the S1 Building Engineering Education (PTB) and S1 Mechanical Engineering Education (PTM) undergraduate programs hold prestigious "Accredited Excellent "(Akreditasi Unggul) status from national accreditation bodies. Nominally, this high-level accreditation implies uniform operational standards and equivalent service delivery across the faculty. However, preliminary observations and student feedback reveal persistent operational bottlenecks and satisfaction gaps, particularly concerning practical laboratory equipment availability, campus facility accessibility, and administrative responsiveness in facility management (Malik et al., 2010; Mulyono et al., 2020). This raises a critical scientific question: Does top-tier institutional accreditation truly guarantee uniform service quality at the program level, or do localized infrastructure and administrative bottlenecks create hidden disparities between technical disciplines?

To address this problem, this study conducts a comparative-descriptive SERVQUAL evaluation across the PTB (n = 215) and PTM (n = 207) programs (N = 422). By examining 23 specific service indicators (P1 through P23), this research seeks to establish the baseline satisfaction levels and dimensional performance gaps across the faculty, while isolating exact operational bottlenecks such as academic laboratory equipment adequacy (P18), general facility accessibility (P23), and administrative responsiveness in facility loan procedures (P16). Furthermore, the investigation aims to verify whether statistically significant disparities in student satisfaction exist between the PTB and PTM programs, and to determine how these empirical SERVQUAL findings can be systematically integrated into the SPMI continuous improvement cycle (PPEPP) and aligned with United Nations SDG 4 targets (Targets 4. a and 4.4).

This study differs substantially from prior publications in three key aspects. Methodologically, rather than presenting a broad, single-institution summary, it uses a granular comparative approach with independent-samples t-tests and Cohen's d effect

sizes to reveal intra-faculty service disparities across specialized engineering fields. Operationally, it translates empirical SERVQUAL item rankings directly into the five-stage SPMI-PPEPP quality management framework (Penetapan, Pelaksanaan, Evaluasi, Pengendalian, Peningkatan), providing a structured roadmap for institutional policy enforcement. Globally, it bridges local academic quality assurance with Sustainable Development Goal 4, demonstrating how resolving practical laboratory and facility bottlenecks directly fosters safe, inclusive learning environments (Target 4.a) and enhances technical skills development for youth employment (Target 4.4). Through this integrated perspective, this study provides both a theoretical contribution to higher education quality management and a practical blueprint for engineering faculties seeking to maintain authentic operational excellence.

RESEARCH METHOD

Research design

This study employed a quantitative comparative-descriptive survey design (Creswell & Creswell, 2017) to evaluate and compare student academic service satisfaction across two "Accredited Excellent" undergraduate engineering programs: Building Engineering Education (PTB) and Mechanical Engineering Education (PTM) at Universitas Negeri Surabaya (UNESA). A cross-sectional survey approach was adopted as it allowed for the objective, non-experimental capture of student perceptions across 23 operationalized SERVQUAL indicators at a specific point in time (Hashimov, 2015). This design was specifically chosen to bridge descriptive diagnostic assessments with inferential hypothesis testing, thereby uncovering latent inter-program operational disparities that aggregate institutional metrics often obscure.

The methodological execution was structured into four sequential phases. First, the conceptualization phase involved adapting the five-dimension SERVQUAL framework into a 23-indicator instrument tailored to the vocational engineering context while adapting practical studio models in technical education (Milošević, 2021). Second, the data collection phase executed a stratified random sampling strategy across active PTB ($n1 = 215$) and PTM ($n1 = 207$) students, yielding a total sample of $N = 422$ respondents. Third, the analytical phase utilized descriptive statistics (Mean, Standard Deviation, and Respondent Achievement Degree/TCR) to establish baseline satisfaction, alongside

inferential statistics (Independent Samples t-test and Cohen's d effect size) to evaluate comparative program disparities. Finally, the policy integration phase mapped the isolated service bottlenecks into UNESA's Internal Quality Assurance System (SPMI-PPEPP cycle) and United Nations Sustainable Development Goal 4 (SDG 4: Quality Education) targets.

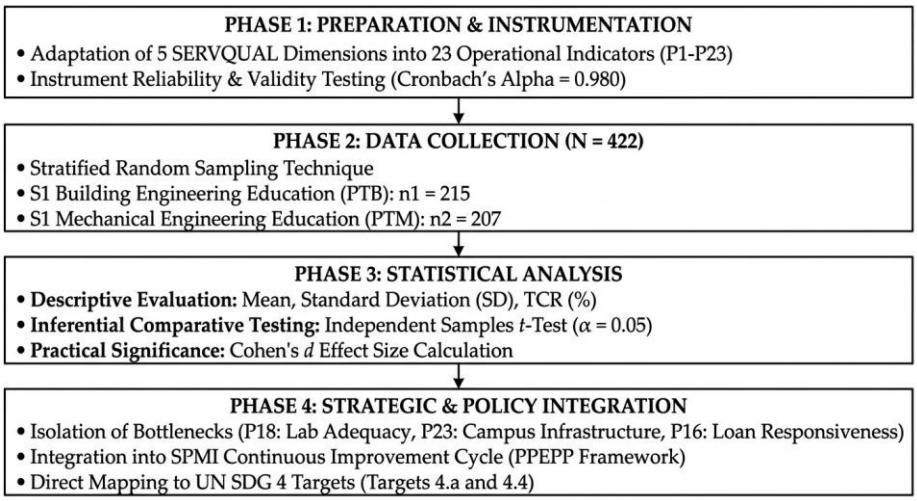

Figure 1. Research design

Population, sample, and sampling technique

The target population for this study comprised active undergraduate students at the Faculty of Engineering, Universitas Negeri Surabaya (UNESA). Using stratified random sampling, respondents were selected from two vocational engineering study programs with "Accredited Excellent" (Akreditasi Unggul) status: S1 Building Engineering Education (PTB, n1 = 215) and S1 Mechanical Engineering Education (PTM, n2 = 207). The final aggregated sample size of N = 422 respondents satisfied the statistical power requirements for descriptive and inferential quantitative testing.

Research instrument and measurement

Data were collected using a structured SERVQUAL questionnaire consisting of 23 service quality indicators (P1 through P23) measured on a 4-point Likert scale ranging from 1 ("Strongly Disagree / Very Dissatisfied") to 4 ("Strongly Agree / Very Satisfied"). We rigorously established content validity and psychometric properties before field administration (Byman, 2016). Table 1 presents the comprehensive matrix of research dimensions, codes, and operational descriptions.

Table 1. Operational matrix of the research instrument

Dimension	Code	Indicator / Operational Description	Scale
Tangible	P1	Accuracy and satisfaction of online and offline academic, administrative, and information services	1–4
Tangible	P5	Adequacy, accessibility, and quality of facilities for student talent and reasoning activities	1–4
Tangible	P9	Availability, adequacy, accessibility, and quality of counseling, health, and scholarship facilities	1–4
Tangible	P13	Availability, adequacy, accessibility, and quality of career guidance and entrepreneurship infrastructure	1–4
Tangible	P18	Adequacy of academic facilities (libraries, laboratories, workshops, electrical supply, internet, and IT systems)	1–4
Tangible	P23	Overall adequacy, accessibility, and quality of general campus infrastructure	1–4
Assurance	P2	Staff attentiveness in receiving grievances regarding student talent and reasoning services	1–4
Assurance	P6	Staff attentiveness in receiving grievances regarding counseling, health, and scholarship services	1–4

Dimension	Code	Indicator / Operational Description	Scale
Assurance	P10	Staff attentiveness in receiving grievances regarding career guidance and entrepreneurship services	1–4
Assurance	P15	Staff attentiveness in receiving grievances regarding financial administration and facilities	1–4
Assurance	P21	Willingness and attentiveness of faculty, administrative staff, and management to pay attention to students	1–4
Responsiveness	P3	Speed and competence of staff in delivering services for student talent and reasoning activities	1–4
Responsiveness	P7	Speed and competence of staff in delivering counseling, health, and scholarship services	1–4
Responsiveness	P11	Speed and competence of staff in delivering career guidance and entrepreneurship services	1–4
Responsiveness	P16	Speed and capability of staff in processing facility and equipment loan requests for student activities	1–4
Responsiveness	P20	Willingness of faculty, administrative staff, and management to render prompt assistance to students	1–4
Empathy	P4	Staff empathy in handling complaints related to student talent and reasoning activities	1–4
Empathy	P8	Staff empathy in handling complaints related to counseling, health, and scholarship administration	1–4
Empathy	P12	Staff empathy in handling complaints related to career guidance and entrepreneurship services	1–4
Empathy	P17	Staff empathy in handling complaints related to financial administration and physical infrastructure	1–4
Empathy	P22	Personalized care and attention provided by faculty, administrative staff, and management to students	1–4
Reliability	P14	Transparency and clarity of SOPs for tuition fee (UKT) payment, delay, or reduction procedures	1–4
Reliability	P19	Overall service delivery competence of faculty, administrative staff, and management	1–4

Data analysis techniques

Data processing and hypothesis testing were performed using SPSS and Python statistical packages, following three main analytical stages:

1. Descriptive statistics and respondent achievement degree (TCR)
   In the first stage, descriptive statistics were calculated to establish the baseline student satisfaction across all 23 SERVQUAL indicators. This involved computing the mean score (Mean), standard deviation (SD), and Respondent Achievement Degree (Tingkat Capaian Responden - TCR) for each item and dimension.

$$TCR = (Mean / k) \times 100 \quad \ldots(1)$$

   The TCR was calculated by expressing the item mean score as a percentage of the maximum scale value (k = 4), allowing student satisfaction to be categorized into standardized qualitative performance intervals to evaluate general service delivery.
2. Inferential comparative analysis (T-Test & Effect Size)
   In the second stage, inferential comparative analysis was conducted to determine whether statistically significant satisfaction disparities existed between students in the S1 Building Engineering Education (PTB) and S1 Mechanical Engineering Education (PTM) programs. An independent-samples t-test was executed at a five

percent significance level ($\alpha = 0.05$). To complement hypothesis testing and assess the practical importance of the identified gaps, Cohen's d effect size was calculated by dividing the mean difference between the two academic programs by the pooled standard deviation, thereby categorizing the practical magnitude of differences as small, medium, or large.

3. Indicator ranking and managerial alignment framework
   In the final stage, we performed an item-granular diagnostic ranking alongside strategic policy alignment. We ranked all 23 service indicators to identify top-performing operational areas and critical service bottlenecks, particularly in academic facility adequacy, general campus infrastructure accessibility, and administrative loan procedures. These empirical outcomes were then integrated into the institutional Internal Quality Assurance System (Sistem Penjaminan Mutu Internal - SPMI) structured around the continuous improvement cycle of Setting, Implementation, Evaluation, Control, and Improvement (PPEPP). Finally, the operational interventions were mapped against United Nations Sustainable Development Goal 4 (SDG 4: Quality Education) targets, specifically Targets 4. a and 4.4, ensuring that internal quality enhancements directly contribute to broader sustainable educational outcomes.

RESULTS AND DISCUSSION

Results

Instrument Validity and Reliability

Before conducting further data analysis, the 23-item SERVQUAL questionnaire (P1 through P23) underwent rigorous validity and reliability testing with $N = 422$ respondents (215 students from S1 Building Engineering Education/PTB and 207 students from S1 Mechanical Engineering Education/PTM).

Reliability testing indicates that all instrument dimensions possess exceptionally high internal consistency. The overall Cronbach's Alpha coefficient was recorded at 0.980, substantially exceeding the standard academic threshold of 0.70.

Table 2. Reliability Testing Results for SERVQUAL Dimensions

SERVQUAL Dimension	Item Codes	Cronbach's Alpha	Reliability Category
Tangible	P1, P5, P9, P13, P18, P23	0.922	Very High
Assurance	P2, P6, P10, P15, P21	0.913	Very High
Responsiveness	P3, P7, P11, P16, P20	0.904	Very High
Empathy	P4, P8, P12, P17, P22	0.918	Very High
Reliability	P14, P19	0.811	High
Total Instrument	P1 - P23	0.980	Very High

Descriptive statistics and comparative analysis

Overall, the accumulative satisfaction level among students at the Faculty of Engineering, Universitas Negeri Surabaya (UNESA), falls within the “Satisfied” category, yielding a total mean score of 3.019 (SD = 0.715) and a Respondent Achievement Degree (TCR) of 75.47%. However, a comparative analysis between the two study programs reveals a noticeable satisfaction gap. Students in S1 Building Engineering Education (PTB) recorded a higher overall mean satisfaction score of 3.088 (TCR= 77.20%), whereas

students in S1 Mechanical Engineering Education (PTM) recorded a mean score of 2.947 (TCR = 73.68%).

Hypothesis testing using an Independent Samples t-Test confirms that this satisfaction disparity is statistically significant at the 5% significance level (t= 2.031; p = 0.0429 < 0.05) with a small-to-medium effect size (Cohen's d = 0.198).

Table 3. Comparative descriptive analysis and independent samples *T*-Test Summary

SERVQUAL Dimension	S1 PTB (N=215) Mean	S1 PTM (N=207) Mean	Combined (N=422) Mean	t-value	p-value	Cohen's d	Significance Status (α = 0.05)
Tangible	3.052 (0.681) 76.30%	2.914 (0.804) 72.85%	2.984 (0.746) 74.60%	1.906	0.0573	0.186	Non-Significant (p > 0.05)
Assurance	3.104 (0.669) 77.60%	2.960 (0.797) 74.00%	3.034 (0.737) 75.85%	2.011	0.0450	0.196	Significant (p < 0.05)
Responsiveness	3.108 (0.649) 77.70%	2.942 (0.781) 73.55%	3.027 (0.721) 75.68%	2.377	0.0179	0.231	Significant (p < 0.05)
Empathy	3.076 (0.676) 76.90%	2.964 (0.808) 74.10%	3.021 (0.745) 75.53%	1.547	0.1227	0.151	Non-Significant (p > 0.05)
Reliability	3.135 (0.704) 78.38%	2.983 (0.850) 74.58%	3.060 (0.782) 76.50%	2.001	0.0460	0.195	Significant (p < 0.05)
Overall Satisfaction	3.088 (0.642) 77.20%	2.947 (0.779) 73.68%	3.019 (0.715) 75.47%	2.031	0.0429	0.198	Significant (p < 0.05)

Identification of top-performing indicators and critical areas

To map the most satisfactory service aspects alongside those requiring urgent managerial intervention, all 23 indicators were ranked based on their grand mean scores.

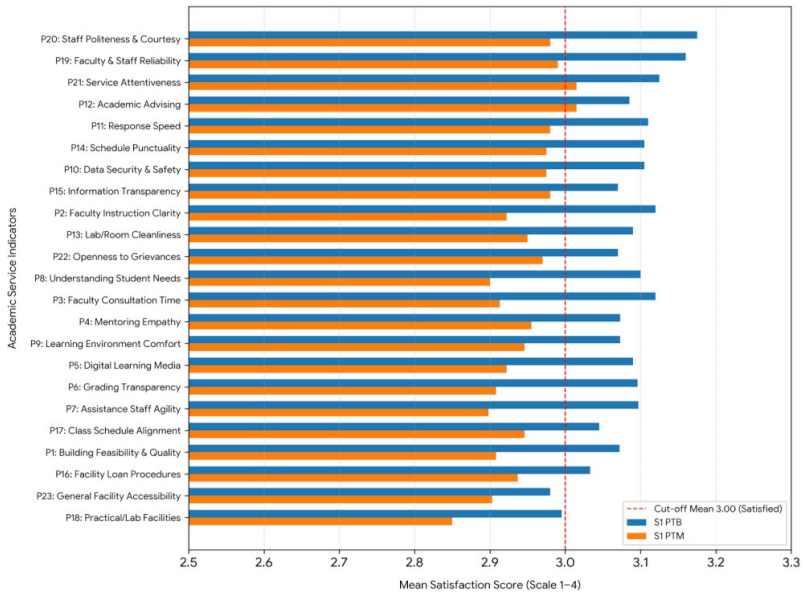

Figure 2. Comparison of academic service satisfaction scores

Discussion

Service satisfaction disparity between S1 PTB and S1 PTM

Although S1 Building Engineering Education (PTB) and S1 Mechanical Engineering Education (PTM) operate under the same faculty governance and both hold "Accredited Excellent" (Akreditasi Unggul) status, this study empirically proves the existence of a statistically significant satisfaction disparity (p = 1.0429).

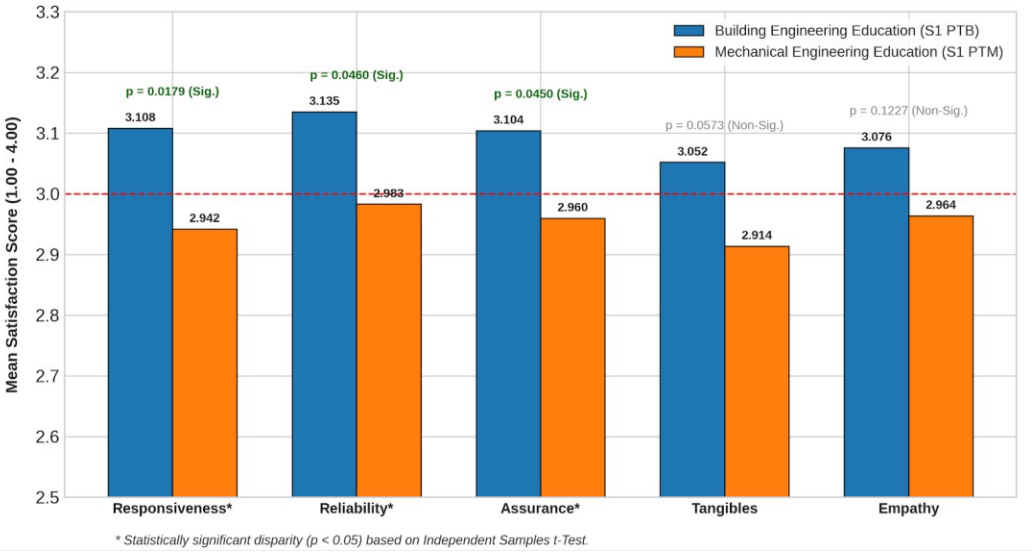

Figure 3. Analysis of service satisfaction disparity across SERVQUAL dimensions (S1 PTB vs S1 PTM)

Responsiveness, p = 0.0179

This dimension represents the most prominent gap between programs. S1 PTM relies heavily on heavy machinery and manufacturing workshops, where technical maintenance and administrative workflows are inherently complex. Operational delays by workshop technicians during practical equipment breakdowns cause PTM students to perceive lower staff responsiveness compared to PTB students, reflecting challenges in technical workload and management efficiency (Altinay et al., 2024; Griffith & Altinay, 2020).

Reliability, p = 0.0460

S1 PTB students reported higher schedule consistency and support system dependability. In contrast, for S1 PTM, equipment downtime during practical sessions frequently disrupts class schedules and delays student final-year thesis testing, underscoring that consistent service delivery directly reinforces student trust and engagement (Chandra et al., 2019; Nasikhah et al., 2024).

Assurance, p = 0.0450

This difference is linked to Occupational Health and Safety (OHS) enforcement and evaluation clarity. The high-risk environment of mechanical workshops demands strict safety guidelines and explicit operational standards (Martin, 2016; Oktarina et al., 2023), whereas civil/building software laboratories present lower physical hazard risks.

Granular diagnosis of critical vocational infrastructure

Item-level ranking reveals that the three lowest-scoring indicators are heavily concentrated within physical facilities and operational procedures:

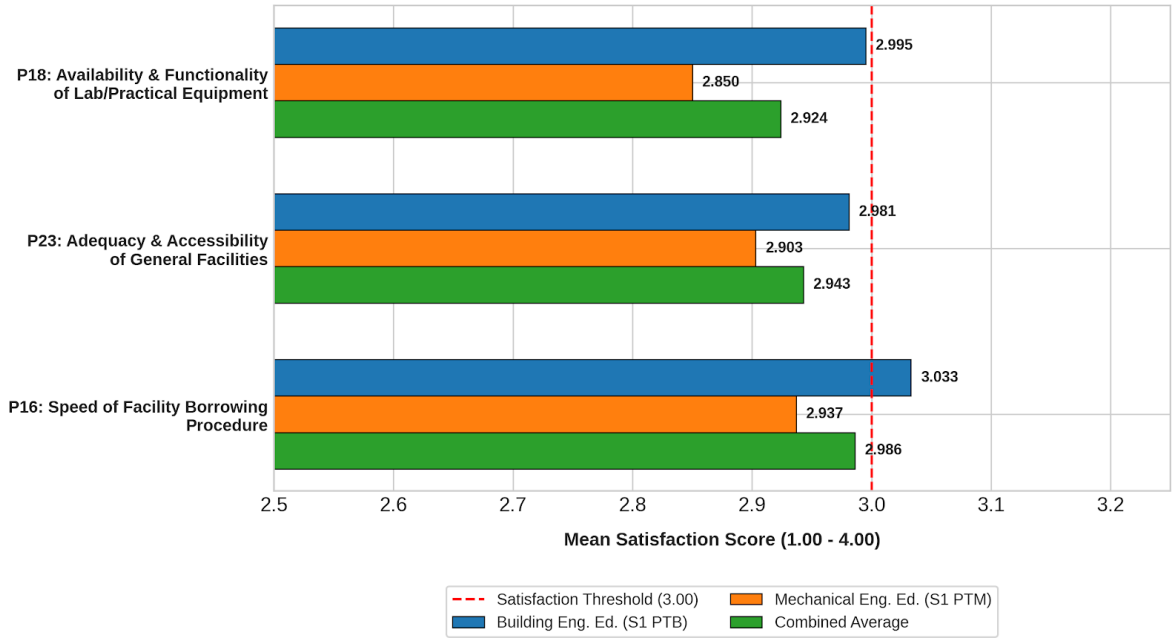

Figure 4. Granular performance breakdown of the bottom-3 critcal service indicators

Availability and functionality of practical equipment (P18 – Mean = 2.924)
This is the weakest service link across the faculty, particularly in S1 PTM (Mean = 2.850). In technical vocational education, fully functional laboratory machinery is essential for building practical competencies. Insufficient student-to-machine ratios and delayed equipment repairs contribute significantly to skills gaps in technical training (Yusvana, 2025).

Accessibility of general supporting facilities (P23 – Mean = 2.943)
General infrastructure such as independent study hubs, prayer room capacities during peak hours, and accessibility options for students with physical disabilities is perceived as inadequate, highlighting the necessity of adaptable learning environments (Hodges et al., 2020).

Bureaucracy in facility loan procedures (P16 – Mean = 2.986)
The approval process for borrowing laboratory facilities for student research remains overly bureaucratic, pointing to a need for greater student participation in institutional administrative decision-making (Perry-Hazan & Somech, 2023).

Implications for the Internal Quality Assurance system (IQA / SPMI)
These empirical findings demonstrate that maintaining an "Accredited Excellent "status requires continuous, data-driven quality control. Implementing ISO-aligned standardization and structured quality management systems (Bouchetara et al., 2022; Vorobyova et al., 2022) ensures continuous monitoring beyond mere compliance (Newton, 2000; Tavares et al., 2017). Within the Indonesian Higher Education Quality Assurance framework, these results are integrated into the Faculty of Engineering's Internal Quality Assurance System (SPMI) through the PPEPP continuous improvement cycle (Setting, Implementation, Evaluation, Control, and Improvement). Standardized learning outcome measurements and self-evaluation models (Hernández-Campos et al., 2025; Seabra et al., 2026) can be utilized to set clear operational standards.

In the Setting (Penetapan) phase, management must revise infrastructure guidelines by capping the student-to-equipment ratio at 1:3 to ensure sufficient hands-on learning. In the Implementation (Pelaksanaan) phase, targeted capital investments should modernize aging workshop machinery in the PTM program. At the same time, a digital facility platform (e-Facility) is deployed across both programs to streamline borrowing procedures (P16).

During Evaluation (Evaluasi), SERVQUAL metrics should be permanently embedded into routine semester-end Internal Quality Audits (Audit Mutu Internal - AMI) to track satisfaction trends. For Control (Pengendalian), dedicated laboratory Preventive Maintenance Units must be established to conduct routine servicing, enforce Occupational Health and Safety (OHS) compliance, and minimize machine downtime—a primary driver of lower PTM satisfaction.

Finally, the Improvement (Peningkatan) phase leverages the higher-performing PTB program as a benchmark to transfer best practices in laboratory administration and staff responsiveness to PTM. This systematic feedback loop eliminates inter-program service disparities and sustains long-term institutional excellence.

Strategic contribution to SDG 4 (Quality Education) targets

Beyond internal quality management, these empirical findings directly advance United Nations Sustainable Development Goal 4 (SDG 4: Quality Education). Aligning vocational quality assurance systems with regional and international standards (Gatt & Faurschou, 2016) ensures that educational outcomes remain competitive and sustainable. Resolving critical bottlenecks in practical laboratory facilities (P18) and general infrastructure accessibility (P23) directly fulfills SDG Target 4.a (building safe, inclusive, and effective learning environments). Furthermore, this operational intervention supports SDG Target 4.4 by strengthening technical and vocational skills development for youth employment.

CONCLUSION

Fundamental Finding: This study proves that "Accredited Excellent" status does not guarantee uniform academic service quality, revealing that: (1) significant satisfaction disparities exist between PTB and PTM programs (N = 422), (2) PTM lags due to infrastructure bottlenecks in lab equipment (P18), facility accessibility (P23), and loan procedures (P16), and (3) high-level accreditation requires continuous, data-driven student validation. **Implication:** These empirical insights bridge institutional governance and global benchmarks by: (1) operationalizing UNESA's SPMI-PPEPP continuous improvement cycle, (2) guiding targeted interventions like equipment modernization and preventive maintenance, and (3) directly advancing UN SDG 4 (Targets 4.a and 4.4). **Limitation:** The study's boundaries are defined by three constraints: (1) a cross-sectional design capturing a single timeframe, (2) a sample restricted to two undergraduate engineering programs at one university, and (3) sole reliance on quantitative student perception data. **Future Research:** To build upon these findings, prospective studies should: (1) employ longitudinal designs to track SPMI-PPEPP policy impacts over time, (2) incorporate qualitative perspectives from administrative staff and lab technicians, and (3) expand comparative evaluations across multiple regional and international universities.

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AUTHOR CONTRIBUTIONS

Yulia Fransisca: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, and Writing-Original Draft. **Subuh Isnur Haryudo:** Methodological Guidance, Validation, Data Analysis, and Writing-Review & Editing. **Khusnul Khotimah:** Investigation, Data Curation, Visualization, and Writing-Review & Editing. **Ali Nur Fathoni:** Investigation, Data Collection, Formal Analysis, and Writing-Review & Editing. **Heri Suryaman:** Supervision, Validation, Technical Guidance, and Writing-Review & Editing. **Mochamad Arif Irfa'i:** Supervision, Conceptual Guidance, Validation, and Writing-Review & Editing. All authors reviewed and approved the final manuscript.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no financial, professional, or personal conflicts of interest that could have influenced the research process, interpretation, or reporting of the findings.

ETHICAL COMPLIANCE STATEMENT

The study followed principles of voluntary participation, informed consent, confidentiality, respectful interviewing, and responsible use of institutional documents. Participant identities are protected through role-based reporting. The supplied dissertation documentation did not record an institutional ethics-review approval or exemption number; therefore, no approval number is claimed in this manuscript. The authors affirm that the article is original and was prepared in accordance with research and publication ethics.

STATEMENT ON THE USE OF AI OR DIGITAL TOOLS IN WRITING

OpenAI's Grammarly was used to support English-language editing, structural refinement, consistency checking, and alignment with the JOCSIS template. The tool was not used to generate, alter, or independently interpret the empirical data. All AI-assisted suggestions were critically reviewed and verified against the source study, and the authors retain full responsibility for the accuracy, originality, and integrity of the final manuscript.

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