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Evaluating the Effectiveness of Laboratory Supervision for Improving Learning Quality in Higher Education Chemistry Practicums

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Abstract: This study examines the effectiveness of laboratory supervision in chemistry practicum activities in higher education. Effective supervision is essential to ensure student safety, structured learning processes, and optimal achievement of learning outcomes. A quantitative survey method was employed involving 88 undergraduate students from a Chemistry Education program who actively participated in chemistry laboratory practicums. Data were collected through structured online questionnaires using a dichotomous (Guttman) scale to capture the implementation of supervision practices. The questionnaire was validated through expert judgment and demonstrated acceptable reliability *(Cronbach's Alpha = 0.705)*. The data were analyzed using descriptive quantitative techniques to determine supervision effectiveness across five aspects *based on predetermined effectiveness criteria*. The results indicate that overall supervision effectiveness reached 81.69% (*Good* category). High effectiveness was found in practicum implementation (90.23%), laboratory assistant guidance (94.91%), equipment and materials (87.40%), and practicum guidelines (93.43%). However, lecturer guidance showed significantly lower effectiveness (42.50%, *Poor* category), indicating a critical gap in direct academic supervision. In conclusion, laboratory supervision has been effectively implemented in most aspects; however, strengthening lecturer involvement remains essential to improve learning quality and support instructional objectives in chemistry practicum activities.

Keywords: Chemistry laboratory; Laboratory supervision; Learning quality; Practicum

Introduction

Chemistry is fundamentally an experimental science in which knowledge is developed through systematic observation and investigation (Rahmi et al., 2023). Accordingly, learning chemistry extends beyond the acquisition of theoretical concepts and requires students to relate these concepts to real-world phenomena encountered in everyday life (Raziana et al., 2025). Experimental activities therefore play a central role in supporting conceptual understanding through direct observation and practice (Junaidi et al., 2018; Adiningsih et al., 2020). In addition, instructional approaches such as inquiry-based, blended, and project-based learning have been shown to improve learning outcomes, strengthen critical thinking, and support long-term retention (Sejati et al., 2023; Zikrina & Supriyanti, 2021; Juniar et al., 2020; Kusumi, 2019).

Laboratory practicums constitute a key component of chemistry education because they provide opportunities for students to apply theoretical knowledge in controlled and contextual environments

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(Side et al., 2024). Many chemistry topics inherently require experimental activities to support the achievement of instructional objectives (Sari et al., 2021). Through these activities, students develop scientific reasoning, problem-solving skills, and active engagement in learning (Gungor et al., 2022). Thus, laboratory practicums serve as an essential bridge between theory and practice and contribute to the overall quality of chemistry learning.

Despite these benefits, laboratory activities also present challenges related to safety risks, procedural errors, and ineffective implementation (Cahyaningrum et al., 2019; Seery et al., 2019). In addition, laboratory conditions have been shown to influence students' motivation and engagement in the learning process (Nadrah, 2025). These challenges underline the importance of effective laboratory supervision to ensure that practicum activities are conducted safely, systematically, and in accordance with instructional objectives. In this study, supervision refers to the roles of lecturers and laboratory assistants in guiding students, monitoring procedures, and ensuring compliance with laboratory standards (Makrifah & Mindiharto, 2021).

Previous studies have demonstrated that effective laboratory supervision contributes to improved learning outcomes and supports the development of scientific skills (Shana & Abulibdeh, 2020; Veale et al., 2020). It also plays a role in minimizing errors, reducing risks, and improving the quality of the learning environment (Saputri et al., 2018). Furthermore, supervision supports the regulation of the learning process, allowing instructional activities to be conducted more systematically (Kotuľáková et al., 2024). However, most existing studies focus on the general benefits of laboratory activities and provide limited discussion on how supervision operates across different aspects of practicum implementation.

In the context of the Chemistry Education Study Program at Tanjungpura University, preliminary observations indicate that laboratory supervision is not consistently implemented, particularly in terms of lecturer involvement during practicum activities. While laboratory assistants actively support technical aspects, lecturer involvement tends to be limited. This condition may affect both the quality of learning and the achievement of instructional objectives. Although the importance of supervision has been widely recognized, there is still limited empirical evidence examining its effectiveness across key components, such as lecturer guidance, assistant support, and laboratory facilities, within higher education settings. This gap makes it difficult to identify which aspects of supervision require improvement to enhance learning quality.

Therefore, this study aims to evaluate the effectiveness of laboratory supervision in chemistry practicum activities by examining several key aspects, including practicum implementation, lecturer guidance, assistant support, equipment conditions, and practicum guidelines. This study provides a comprehensive assessment of supervision effectiveness and offers empirical evidence to support efforts to improve the quality of chemistry learning in higher education.

Method

This study employed a quantitative approach using a survey method to systematically describe the effectiveness of laboratory supervision in chemistry practicum activities (Creswell & Creswell, 2018). The research population consisted of students from the Chemistry Education Study Program at Tanjungpura University. The sample comprised 88 students, selected through purposive sampling, focusing on those who actively participated in laboratory practicums.

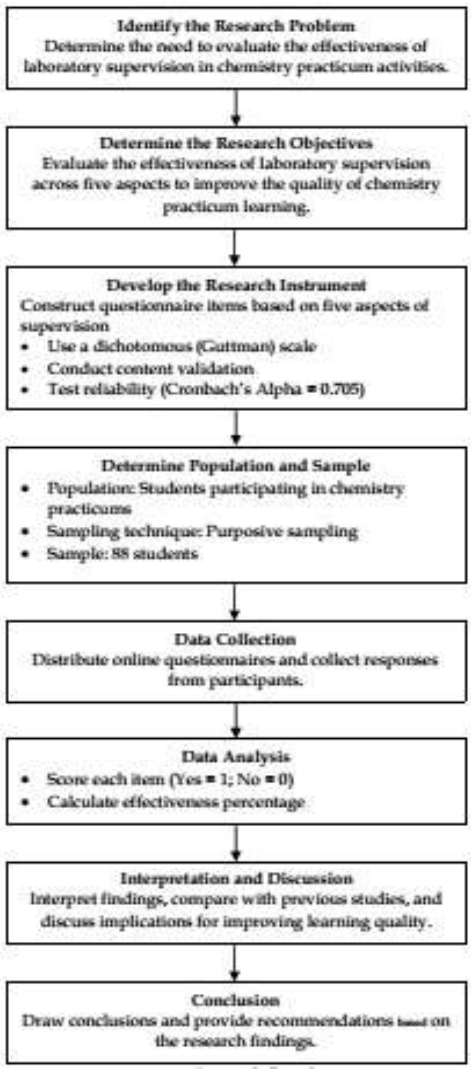

Figure 1. Research flowchart

Data were collected using structured online questionnaires distributed to the selected respondents. The instrument was designed to measure the effectiveness of laboratory supervision across five main aspects: practicum implementation, lecturer guidance, laboratory assistant guidance, equipment and material availability, and practicum guidelines. The instrument consisted of 24 items, which were systematically developed to represent each aspect of laboratory supervision. The detailed items of the instrument are presented in Table 1.

Content validity was established through expert judgment involving specialists in chemistry education and educational management. The reliability of the instrument was assessed using Cronbach's alpha coefficient, which yielded a value of 0.705. This value exceeds the recommended threshold of 0.70 (Shrestha, 2021), indicating acceptable internal consistency. Therefore, the instrument is considered sufficiently reliable to measure the intended constructs (Eisenmann et al., 2021).

The instrument employed a Guttman scale, using dichotomous responses (1 = yes/agree, 0 = no/disagree). The use of this scale was intended to capture the actual implementation of laboratory supervision practices rather than respondents' subjective perceptions. Each item was designed to verify whether specific supervision activities had been carried out during practicum sessions. Therefore, dichotomous responses were considered appropriate to provide clear and objective information regarding the presence or absence of these practices. This approach also minimizes response bias and allows for a more direct assessment of supervision effectiveness in practice. The overall procedure of this study is summarized in Figure 1.

Table 1. Instrument Items of Laboratory Supervision

Aspect	Item no.	Statement
Practicum implementation	1	The experimental procedures follow the practicum guide.
	2	The practicum activities are conducted according to the prescribed procedures.
	3	All practicum activities outlined in the guide can be implemented.
	4	The practicum duration is consistent with the allocated time (1 credit = 170 minutes).
Lecturer guidance	5	The lecturer provides guidance to students when needed during practicum.
	6	The lecturer supervises occupational health and safety (OHS) during practicum.
	7	The lecturer monitors the overall practicum activities.
Laboratory assistant guidance	8	The laboratory assistant prepares the required practicum equipment.
	9	The laboratory assistant checks the functionality of the equipment.
	10	The laboratory assistant supervises the implementation of practicum activities.
	11	The laboratory assistant ensures that practicum activities run according to procedures.
	12	The laboratory assistant provides guidance according to the practicum schedule.
	13	The laboratory assistant maintains order during practicum activities.
	14	The laboratory assistant conducts practicum assessments (pretest/posttest and reports).
	15	The laboratory assistant coordinates with the lecturer during practicum activities.
	16	The laboratory assistant assists the lecturer in preparing assessment materials.
Equipment and materials availability	17	The laboratory equipment is in proper condition (clean, intact, and functional).
	18	The types of equipment available match the practicum requirements.
	19	The quantity of equipment is sufficient for student groups.
	20	The available chemicals meet the practicum requirements.
Practicum guidelines	21	The language used in the practicum guide is clear and easy to understand.
	22	The practicum guide includes laboratory rules and regulations.
	23	The selection of equipment and chemicals aligns with the practicum objectives.
	24	The pretest/posttest questions align with the practicum objectives.

Each respondent's score was calculated by summing the item scores across all indicators. The aggregated scores were then converted into percentage values to represent the level of supervision effectiveness. The percentage score was calculated using the following formula:

$$\text{Percentage} = \frac{\text{total observed score}}{\text{maximum possible score}} \text{ x } 100\% \quad (1)$$

where the maximum possible score represents the total number of items multiplied by the number of respondents. This conversion enabled the classification

of supervision effectiveness based on predetermined criteria.

Data were analyzed using descriptive quantitative techniques to describe the level of laboratory supervision effectiveness. The results were categorized into effectiveness levels based on percentage intervals adapted from Trisnawati et al. (2018), as presented in Table 2. Furthermore, the analysis was conducted by grouping the results based on the five aspects of supervision and by examining item-level responses (Items 1–24) to identify specific strengths and weaknesses in laboratory supervision practices.

Table 2. Classification of Supervision Effectiveness

Percentage	Classification
84-100	Excellent
68-83	Good
52-67	Fair
36-51	Poor

Result and Discussion

Chemistry practicum activities are routinely conducted in higher education settings. The results of this study indicate that the overall effectiveness of laboratory supervision in chemistry practicum activities reached 81.69%, which falls into the Good category based on the predetermined classification criteria. This finding suggests that, in general, laboratory supervision practices have been implemented effectively across the observed aspects. As presented in Figure 2, the effectiveness of laboratory supervision varies across five aspects: practicum implementation, lecturer guidance, laboratory assistant guidance, equipment and material availability, and practicum guidelines. Most aspects demonstrate high levels of effectiveness, while lecturer guidance remains the lowest, indicating an imbalance in supervision practices.

Further analysis is presented in Figure 3, which illustrates supervision effectiveness across 24 questionnaire items. The blue line represents the average effectiveness (81.69%), while the orange line shows variations across individual items. Items 1–4, which represent practicum implementation, show consistently high effectiveness. These findings indicate that experimental procedures were carried out according to the practicum guide, all planned activities were successfully implemented, and the duration of practicum sessions aligned with the allocated time. Previous studies have shown that structured scheduling, such as block scheduling combined with pre-laboratory preparation (e.g., videos and simulations), can improve practical skills while reducing cognitive load (Lau et al., 2022; Harilal et al., 2024). In addition, the integration of active and inquiry-based approaches has been shown to enhance both conceptual understanding and practical skills (Ali et al., 2023). Pre-laboratory preparation also plays an important role in equipping students with conceptual readiness and procedural planning before entering laboratory activities (Lestari et al., 2025).

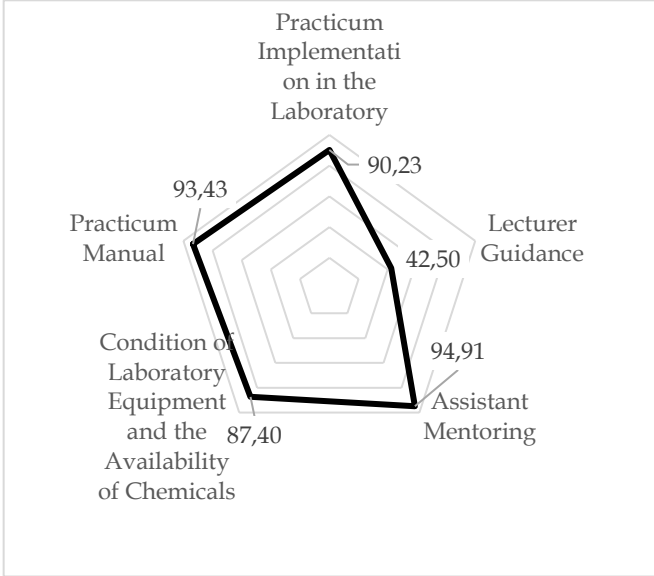

Figure 2. Results of the supervision of practicum activities in each aspect

In contrast, a significant decline is observed in items 5–7, which represent lecturer guidance, with an effectiveness level of 42.50%, categorized as Poor. These items indicate limited lecturer involvement in providing guidance, supervising occupational health and safety (OHS), and monitoring practicum activities. This finding suggests that lecturer participation during practicum sessions is relatively low, particularly in continuous supervision beyond initial instructions.

This condition is influenced by several factors, including high teaching workloads, overlapping academic responsibilities, and limited time allocation for laboratory supervision. Practicum activities inherently involve direct interaction between lecturers and students, integrating cognitive, psychomotor, and affective domains (Sari et al., 2022). In this context, learning is ideally student-centered, where lecturers act as facilitators rather than dominant instructors (Mustika et al., 2022). Frequent and high-quality interaction has been shown to positively influence student motivation, engagement, and academic performance (Abed et al., 2024). Furthermore, the evolving chemistry curriculum, particularly with the integration of inquiry-based and technology-enhanced learning, has expanded the role of supervisors from procedural oversight to facilitators, mentors, and providers of feedback (Widiasih et al., 2025; Seery et al., 2024).

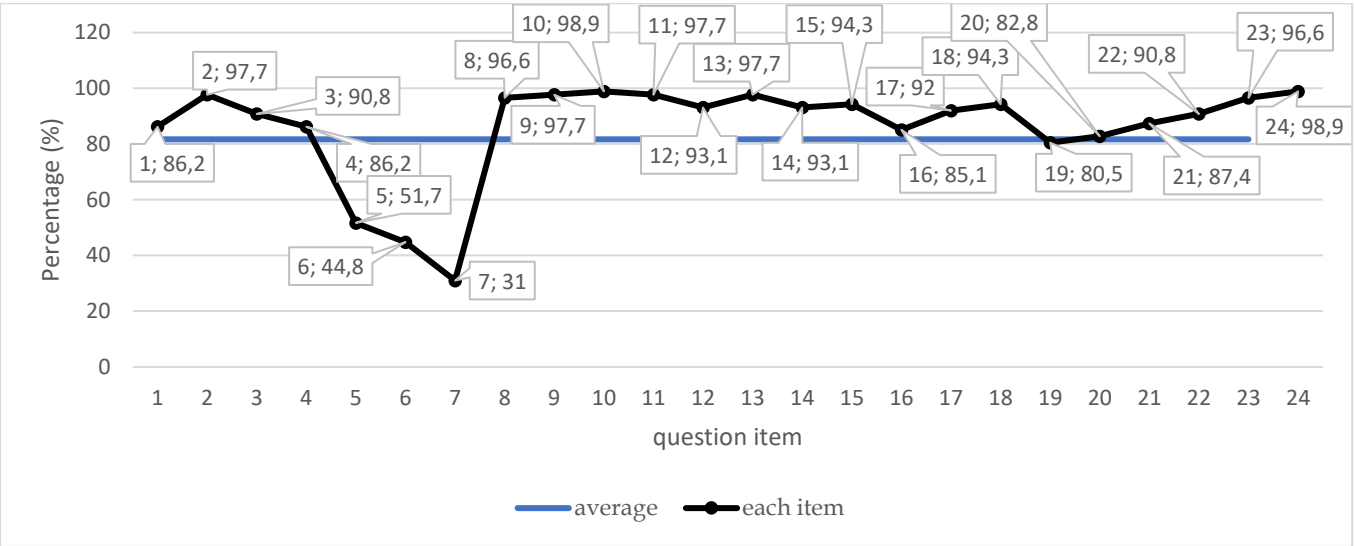

Figure 3. Supervision of practices based on each question

In addition, institutional policies may shift operational responsibilities toward laboratory assistants, thereby reducing lecturer involvement in practicum activities. This finding is consistent with previous research emphasizing that active lecturer involvement is essential for achieving effective practicum learning outcomes (Wahyudiati, 2016). Similarly, supervised laboratory instruction has been shown to significantly enhance student understanding and motivation (Ali et al., 2023).

Items 8–16, which represent laboratory assistant guidance, show very high effectiveness (94.91%, *Excellent*). These findings indicate that laboratory assistants actively prepared equipment, ensured its functionality, supervised practicum activities, maintained order, and conducted assessments. This result aligns with previous studies highlighting the importance of laboratory assistants in maintaining the continuity and effectiveness of laboratory activities (Saputra & Septiana, 2022; Makrifah & Mindiharto, 2021). In addition, peer-assisted learning and mentoring approaches have been widely recognized as effective in improving student engagement and reflective learning, with recent studies further reinforcing these findings (Saeidi & Earthman, 2024; Gruver et al., 2024; Maggard et al., 2026; Haugen & Sundby, 2020; Reck, 2017).

Items 17–20, which represent equipment conditions and material availability, show high effectiveness (87.40%, Excellent). The results indicate that laboratory equipment was in proper condition, suitable for practicum activities, and available in sufficient quantities. This finding is supported by previous studies showing that systematic monitoring of equipment can prevent operational failures and improve efficiency (Sansana et al., 2023). Conversely, inadequate or poorly maintained equipment can reduce the effectiveness of laboratory activities (Jaya et al., 2020). Although the procurement of laboratory equipment and chemical materials requires considerable cost, integrating practicum-based learning remains essential in chemistry education (Mardhiya & Laila, 2022).

Items 21–24, which represent practicum guidelines, show high effectiveness (93.43%, Excellent). The results indicate that the practicum guide is clearly written, includes laboratory rules, and aligns the selection of equipment, materials, and assessment components with practicum objectives. Well-designed practicum guidelines provide a structured framework that supports effective learning processes and improves the achievement of instructional objectives (Seery, 2020; Juniar et al., 2020).

Overall, the findings indicate that the effectiveness of laboratory supervision is influenced by the synergy between lecturer involvement, laboratory assistant support, and the availability of laboratory facilities. While most aspects have been implemented effectively, the limited role of lecturers remains a critical issue. Strengthening lecturer supervision through structured scheduling, increased engagement (Nurmayanti & Ferdiansyah, 2021), and continuous evaluation (Erwin et al., 2018) is essential to improve learning quality in chemistry practicum activities. Without adequate lecturer involvement, the potential of laboratory learning to develop students' scientific competencies may not be fully achieved. In addition to established findings, recent studies have begun to highlight emerging approaches to strengthening laboratory supervision, including metacognitive strategies, technology integration, and inclusive practices, which are increasingly recognized as important for improving the quality of chemistry learning (Dewi et al., 2026; Hunpinyo et al., 2026; Khmel & Shpyrka, 2025).

Conclusion

The effectiveness of laboratory supervision in chemistry practicum activities reached 81.69%, which falls into the Good category based on the predetermined classification criteria. This indicates that, overall, laboratory supervision practices have been implemented effectively in supporting practicum activities and learning processes. However, a key finding of this study is the low effectiveness of lecturer guidance (42.50%), which is categorized as Poor. This result highlights a significant imbalance in supervision practices, where technical and operational aspects, particularly those supported by laboratory assistants and facilities, have been implemented effectively, while direct academic supervision by lecturers remains limited. The findings of this study, based on an implementation-focused measurement using dichotomous (Guttman) responses, indicate that most supervision activities have been carried out in practice. However, limited lecturer involvement may reduce the effectiveness of supervision in achieving deeper conceptual understanding and scientific reasoning among students. Therefore, strengthening lecturer involvement through structured scheduling, increased presence during practicum sessions, and continuous evaluation is essential to enhance learning quality, ensure laboratory safety, and optimize the achievement of instructional objectives in chemistry practicum activities. Future research is recommended to further investigate factors influencing limited lecturer involvement, such as workload distribution, institutional policies, and time constraints. In addition, the use of mixed-method approaches is suggested to provide deeper insights into the effectiveness of laboratory supervision and student learning experiences in different educational contexts.

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Author Contributions
Conceptualization, R.P.S. and L.H.; methodology, R.P.S.; validation, H.A and A.I.P.; formal analysis, R.P.S.; investigation, R.P.S and L.H.; resources, L.H.; data curation, R.P.S; writing—original draft preparation, R.P.S and L.H.; writing—review and editing, R.P.S and A.I.P.; visualization, G.F.A. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest
The authors declare no conflict of interest.

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