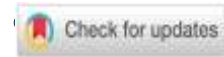




Exploration of students' perceptions of science practicals as a bridge to meaningful learning



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ABSTRACT

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Twenty-first-century science education requires not only conceptual mastery but also the development of scientific process skills and critical thinking. Laboratory work plays a central role in achieving these goals; however, its effectiveness is often limited by “cookbook-style” procedures that fail to promote deep cognitive engagement. This study aimed to explore students’ perceptions of science practicums as indicators of Meaningful Learning (Pembelajaran Bermakna/PBM). Using a qualitative approach with an exploratory case study design, this research involved twelve purposively selected Grade VIII students. Data were collected through in-depth interviews, non-participant observation, and documentation, and were analyzed using thematic analysis. The findings indicate that students perceive meaningful learning as conceptual understanding that can be applied to everyday life rather than mere memorization. Science practicums were viewed as an effective means of achieving PBM, particularly due to the quality of teacher guidance, clear instructions, and opportunities for group collaboration. Although limited laboratory equipment and materials were identified as the main constraints, these limitations did not substantially hinder students’ conceptual understanding. The study concludes that strong pedagogical interactions can bridge hands-on and minds-on learning and support the implementation of competency-based curricula.

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INTRODUCTION

Science education in the 21st century faces increasingly complex challenges, alongside global demands to produce a generation that not only masters knowledge but also can think critically,



solve problems, and apply scientific concepts in real-world contexts (Al-Kamzari & Alias, 2025). These competencies cannot be achieved solely through conventional lecture-based learning but by digital media (Solihin, Mailayfaiza, et al., 2025), like media KA, virtual lab, and robotics (Solihin S et al., 2025). Laboratory practice and science practica are crucial components in supporting students' process skills, developing conceptual understanding, and enhancing analytical thinking (Fantinelli et al., 2024). Practicums enable students to observe, experiment, and reflect on scientific phenomena, so they not only understand theory abstractly but also are able to relate it to everyday reality. Practical lab work should combine students' physical involvement in experiments (hands-on) with deep cognitive engagement (minds-on), such as a virtual lab (Syafkitamsana et al., 2025). Balancing these two aspects is key to ensuring meaningful learning (Fantinelli et al., 2024). However, research shows that laboratory work in many schools still tends to be "cookbook-style," where students follow standard procedures without understanding the underlying scientific principles. This creates a gap between the potential of laboratory work as an active learning tool and its actual implementation, constrained by curricular constraints, time, and available laboratory facilities (Kim et al., 2025).

The concept of Meaningful Learning emphasizes the importance of linking new information to students' existing cognitive structures. (Newman, 2005). In the context of science labs, this means that students not only conduct experiments but also understand scientific principles, analyze experimental results, and relate these findings to real-world experiences. (Hamadneh et al., 2025). Previous studies have confirmed that the success of labs in supporting Meaningful Learning is influenced by several key factors, including the quality of teacher guidance, clarity of instructions, and opportunities for group collaboration (Hacieminoğlu et al., 2022). Teachers who can facilitate scientific reflection and discussion can strengthen the mind-on process, resulting in deeper student understanding (Hacieminoğlu et al., 2022).

On the other hand, logistical constraints remain a significant challenge to the effectiveness of practicums (Surata, 2020). Limited laboratory equipment and materials, limited space, and short lab time allocations often hinder optimal learning experiences. (Okada et al., 2025). Some schools even require students to bring their own equipment, which can impact the quality of learning. However, recent literature suggests that effective pedagogical interactions between teachers and students can mitigate these limitations (Karnadi et al., 2021). Teachers who act as active facilitators, reflection facilitators, and providers of constructive feedback can bridge the gap between hands-on and minds-on learning (Rafiq-uz-Zaman & Nadeem, 2025). Students' perceptions of science lab work are an important indicator in evaluating its effectiveness. Students who perceive lab work as meaningful experiences tend to demonstrate higher engagement, deeper conceptual understanding, and increased motivation to learn. In Indonesia, particularly in junior high schools, research on students' perceptions of lab work is still limited. Most studies focus on learning outcomes or lab work skills, without exploring how students interpret their learning experiences and connect them to Meaningful Learning. This indicates a gap that needs to be filled through contextual studies, particularly in schools with limited resources, such as SMP Negeri 22 Jakarta, where science laboratory work is conducted routinely but is constrained by limited laboratory facilities and time constraints (Rocha et al., 2023).

The novelty of this research lies in its focus on exploring student perceptions as a bridge between practicum experiences and the achievement of Meaningful Learning. This approach differs from conventional studies, which typically assess the effectiveness of practicums through test results or teacher observations (Adetunji, 2025). Exploring student perceptions is also crucial for understanding the psychosocial dimensions of practicums, including motivation, self-confidence, and collaboration skills. Students who experience autonomy, peer social support, and success in practicum placements tend to connect learning to real-life experiences, making the practicum

experience more meaningful (Jiang et al., 2025). In addition to pedagogical and psychosocial aspects, students' perceptions of the quality of teacher guidance, instruction, and experimental group interactions play a role in shaping positive attitudes toward practicums. Teachers who are able to provide real-world application contexts increase the relevance of the material and strengthen students' conceptual understanding. Technical barriers such as limited equipment do not necessarily reduce the effectiveness of practicums if supported by appropriate pedagogical strategies, including the use of alternative media, simulations, or adaptive learning group arrangements. This study also emphasizes the importance of integrating the Independent Curriculum, which demands active, contextual, and competency-based learning. Science practicums serve as a strategic means to implement these principles by strengthening process skills, collaboration, and scientific reflection.

Thus, this study offers a dual contribution. First, it provides an empirical overview of students' perceptions regarding science practicums in Indonesian junior high schools (Yatimah et al., 2019). Second, it provides practical recommendations for designing more meaningful practicums, even with limited facilities. This study employed a qualitative approach with a case study design, enabling an in-depth understanding of students' learning experiences and the factors that shape their perceptions. This approach is crucial for capturing the complexity of pedagogical interactions, logistical constraints, and students' social contexts (Verawati et al., 2025).

RESEARCH METHODS

Research Design

This study uses a qualitative approach with an exploratory case study design to understand junior high school students' perceptions of science practicums as a bridge to meaningful learning. The qualitative approach was chosen because it allows researchers to explore students' experiences, meanings, and interpretations in depth, holistically, and contextually (Solihin, Bae, et al., 2025). This study employed a qualitative descriptive research design with a thematic approach. This design was selected to explore in depth students' perceptions of science practicum activities and their contribution to meaningful learning. A qualitative approach was considered appropriate because the research focused on understanding experiences, interpretations, and meanings constructed by students rather than on testing hypotheses or measuring variables statistically. Thematic organization of the findings enabled the researchers to identify recurring patterns in students' responses. In addition, the use of verbatim quotations strengthened the authenticity and trustworthiness of the data. Overall, this design allowed the study to capture rich, contextualized insights into science learning through practical activities.

Population and Samples

The focus of this study is a single case study (*bounded case*), namely the perception of Class VIII students at SMP Negeri 22 Jakarta regarding the implementation of science practicums, so that the case study design is considered most appropriate for capturing the complexity of contextual phenomena. Research participants were selected using purposive sampling techniques to ensure a relevant representation of the research objectives. The participant selection criteria included: active students in Grade VIII who had practical experience in Grades VII and VIII, a variety of academic abilities (high, medium, low) based on recommendations from science teachers, gender balance, as well as adequate communication skills and a willingness to share experiences voluntarily (Morris, 2025). The estimated number of participants is 12 students, but the data collection process will continue until saturation is reached, namely, when additional data no longer produces significant new information.

The population of this study consisted of Grade VIII students of SMP Negeri 22 Jakarta who participated in science practicum activities. From this population, a sample of twelve students



(n = 12) was selected as research participants. These students were chosen because they were directly involved in the practicum sessions and were therefore able to provide detailed and relevant information regarding their learning experiences. The relatively small sample size is consistent with qualitative research principles, which emphasize depth of understanding rather than broad generalization. Each participant contributed individual perspectives that enriched the overall findings. Thus, the sample was considered adequate to represent variations in students' perceptions of science practicum-based learning.

Instruments

Data collection was conducted through triangulation methods to obtain rich and comprehensive data. First, in-depth interviews (*in-depth interviews*) was used as the primary technique to explore students' perceptions, experiences, understandings, and expectations regarding science practicums. The interviews were semi-structured, with flexible guidelines based on the research problem formulation. Example questions included: "Tell me what you understand about meaningful learning?" "How was your experience participating in science practicums?", and "What made the practicums feel relevant to the material in class?" Interviews were recorded with the participants' permission and transcribed verbatim for further analysis (Aisyah & Novita, 2025).

Second, non-participant observations were conducted during 2–3 lab sessions in different classes. The goal was to examine the context in which the lab was conducted, including student-student interactions, student-teacher interactions, the use of tools and materials, the flow of activities, and the learning atmosphere. The researcher acted as a passive observer, systematically recording findings in field notes. Third, a documentation study is conducted to complete and verify the data, including documents such as Student Worksheets (LKS) for practical work, student practical reports, teacher Learning Implementation Plans (RPP), and visual documentation of activities (photos/videos if permitted).

The primary research instrument used in this study was in-depth interviews. An interview guideline was developed to ensure that the discussions addressed key aspects of the research focus, including students' conceptual understanding, learning activities, teacher support, and perceived obstacles during practicums. The interviews allowed participants to express their experiences freely and in their own words. Students' responses were recorded and transcribed to maintain data accuracy. Verbatim quotations were later used in the results section to support the identified themes and to enhance the credibility of the study.

Procedures

The research procedures began with the implementation of science practicum activities involving the selected students. After the practicum sessions, in-depth interviews were conducted to gather students' reflections on their learning experiences. Data collection took place in October 2025 to ensure that students' responses were based on recent and direct engagement with laboratory activities. The interviews were conducted in a structured but flexible manner, allowing probing questions when necessary. All collected data were organized systematically in preparation for analysis. This step-by-step procedure ensured that the research process was coherent and methodologically sound.

Data Analysis

Data analysis used a qualitative phenomenological approach, focusing on students' experiences and perceptions. The collected data were analyzed using Thematic Analysis, following the steps of Putri & Wardani, (2021). The analysis process began with familiarization with the data through repeated readings of interview transcripts, field notes, and documents. Next, initial

codes (initial coding) are assigned to data segments relevant to the research question. These codes are then grouped into potential themes (searching for themes), which is reviewed to ensure internal coherence and external clarity (reviewing themes). Each theme is defined and given a concise name (defining and naming themes), then compiled into an analytical narrative that integrates verbatim quotations from participant data (producing the report).

To increase the credibility and validity of the findings, this study employed several data validation techniques. Triangulation was conducted both between sources (comparing the perceptions of students from different ability backgrounds) and between methods (comparing findings from interviews, observations, and documentation). Additionally, member checking was implemented by conveying temporary interpretations to several participants to ensure appropriateness of meaning. Audit trail (audit trail) is also maintained through detailed recording of the entire research process, from raw data collection to theme formation.

The collected data were analyzed using thematic analysis. All interview transcripts were read repeatedly to achieve data familiarization, after which meaningful units were systematically coded and organized into main themes and subthemes. The identified themes were subsequently presented in tabular form and supported by frequency distributions, percentages, and in-depth narrative interpretations. The findings indicate that science practicum activities contribute significantly to the development of meaningful learning by strengthening students' conceptual understanding, promoting active engagement, and fostering positive attitudes toward science learning. Teacher guidance and group collaboration emerged as the most influential supporting factors, while limited laboratory facilities and restricted practicum time were identified as the primary obstacles. Overall, these findings demonstrate that well-designed and pedagogically supported practicum activities play a crucial role in bridging theoretical knowledge and real-world scientific understanding

RESULTS

The research results are presented based on five main themes that align with the established problem formulation, with a focus on findings from in-depth interviews conducted in October 2025.

Table 1. Supporting Factors for Science Practicals as a Bridge to PBM.

Main Theme	Subthemes / Supporting Factors	Number of Students (n=12)	Percent age (%)	Example of Verbatim Quotation
Pedagogical Factors	Clear teacher guidance	10	83,3	"The teacher always explains the experimental steps in detail, so I understand better."
	Group collaboration	9	75,0	"Studying in groups allows me to exchange ideas and understand concepts more quickly."
Contextual Factors	The relationship between practical material and everyday life	8	66,7	"I now know why the chemical reaction occurs, because I saw it in the kitchen."
Facility Factors	Availability of LKS / supporting materials	7	58,3	



Based on the data in Table 1, students' perceptions of meaningful learning are influenced by a combination of pedagogical, contextual, and learning facility factors. Pedagogical factors are the most dominant, obvious, and structured teacher guidance, which was acknowledged by the majority of students (83.3%). The clarity of teacher instructions in explaining the practicum steps helped students understand procedures and concepts more systematically, thus minimizing confusion during the learning process. Furthermore, group collaboration was also an important supporting factor (75.0%), as interaction between students allowed for the exchange of ideas, discussion, and collaborative problem-solving, which strengthened conceptual understanding.

In addition to pedagogical aspects, contextual factors and facilities also contribute to students' meaningful learning experiences. Connecting the lab material to everyday life (66.7%) helped students connect scientific concepts with real-life experiences, making learning less abstract and easier to understand. Meanwhile, the availability of worksheets (LKS) and supporting materials (58.3%) was considered quite helpful, although not yet fully optimal. These findings indicate that, despite perceived facility limitations, meaningful learning can still be achieved if supported by effective pedagogical strategies and the relevance of the material's context to students' lives.

Table 2. Barriers to Science Practicals According to Student Perceptions

Main Theme	Subtheme / Obstacles	Number of Students (n=12)	Percentage (%)	Example of Verbatim Quotation
Technical / Logistical Barriers	Limited tools and materials	11	91,7	"Some tools are not available in the laboratory, so you have to bring them from home."
	Limited practicum time	8	66,7	"The practicum felt rushed because the time was so short."
Barriers to Understanding	Difficulty understanding procedures	5	41,7	"Sometimes the experimental steps are confusing; you have to ask the teacher again."
Interaction Barriers	Lack of teacher interaction	3	25,0	"Sometimes teachers are busy with other groups, so they do not get enough guidance."

Based on the data in Table 2, the main obstacles to implementing science practica, according to students' perceptions, were technical and logistical. Limited tools and materials were the most significant obstacle experienced by almost all students (91.7%). This condition required students to either bring their own materials from home or share them with other groups, which could disrupt the continuity and focus of the practicum activities. Furthermore, limited practicum time was a significant obstacle (66.7%), often resulting in the experimental process being perceived as rushed and leaving insufficient time for students to explore concepts in depth.

On the other hand, barriers related to pedagogical understanding and interaction were less pronounced. Some students (41.7%) still had difficulty understanding lab procedures, although this issue was generally resolved through additional clarification from the teacher. Interaction barriers in the form of a lack of teacher guidance were only experienced by a small proportion of students (25.0%), indicating that the teacher's role was generally adequate. These findings suggest that the main obstacles to science laboratory work are more structural and managerial than pedagogical, making improvements in facilities and time management a priority for enhancing the quality of meaningful learning.

Table 3. Student Activities during Practicum

Activity	Number of Students (n=12)	Percentage (%)	Examples of Verbatim Quotations
Following the teacher's instructions	12	100,0	"I always follow the steps explained by the teacher."
Group discussion	9	75,0	"The discussion made me understand concepts that were not yet clear."
Recording observations	11	91,7	"Recording the results of the experiment helps me understand the concept better."
Analyzing the results of the experiment	8	66,7	"I can see the connection between theory and real experimental results."

Based on Table 3, student activities during the practicum demonstrated a high level of engagement in both cognitive and procedural aspects. All students (100%) followed the teacher's instructions, indicating that pedagogical guidance was the primary foundation for the practicum. Compliance with these instructions reflected the clarity of the work steps and students' trust in the teacher's guidance as a learning facilitator. Furthermore, almost all students (91.7%) recorded their observations, which played a crucial role in helping students reflect on the experimental process and strengthening conceptual understanding through empirical data.

Activities requiring higher-level cognitive engagement also emerged. Most students participated in group discussions (75.0%), which served to clarify concepts and exchange ideas among group members. Furthermore, two-thirds of students (66.7%) were able to analyze experimental results and relate them to previously learned theories, demonstrating the development of analytical thinking skills and conceptual understanding. These findings indicate that the laboratory work not only encourages mechanical activity but also facilitates meaningful learning by integrating empirical experience and theoretical knowledge.

Table 4. Student Perceptions of Meaningful Learning (PBM)

Aspects of PBM	Number of Students (n=12)	Percentage (%)	Examples of Verbatim Quotations
Understanding of applicable concepts	10	83,3	"I can relate the theories I learn to everyday examples."
Active involvement	9	75,0	"I am more active in asking questions and trying because the practicals are interesting."
Motivation to learn increases	8	66,7	"The practicum made me more enthusiastic about understanding science."
Increased self-confidence	7	58,3	"I dare to try experiments on my own without fear of making mistakes."

Based on the data in Table 4, students' perceptions of meaningful learning (PBM) show a very positive trend, particularly in understanding applicable concepts. The majority of students (83.3%) reported that they were able to relate theoretical concepts to everyday contexts, indicating the essence of PBM as the integration of new knowledge with real-life experiences. This finding suggests that lab-based learning plays a crucial role in helping students develop functional, non-abstract understanding.

In addition to conceptual understanding, PBM also impacts students' affective and participatory aspects. Most students demonstrated active engagement in learning (75.0%),



characterized by their courage to ask questions and experiment during the practicum. Increased learning motivation (66.7%) and self-confidence (58.3%) further indicate that PBM not only facilitates cognitive development but also fosters positive attitudes toward science learning. Overall, these findings confirm that pedagogically designed practicums can create meaningful, active, and empowering learning experiences for students.

Table 5. Teacher Support in Science Practicum

Forms of Teacher Support	Number of Students (n=12)	Percentage (%)	Examples of Verbatim Quotations
Provide clear instructions	10	83,3	“The teacher's instructions were easy to understand, so the experiment went smoothly.”
Facilitating reflection	9	75,0	“Teachers always ask ‘why’ so we think deeper.”
Providing constructive feedback	8	66,7	“The teacher's feedback helped me correct my experimental errors.”

Based on Table 5, students perceived teacher support in implementing science practicums as a key factor in creating meaningful learning. The majority of students (83.3%) considered clear, easy-to-understand teacher instructions very helpful in ensuring the smooth running of the practicum, particularly in understanding the experimental stages and objectives. This clarity of instruction contributed to a reduction in procedural errors and an increase in student confidence during the experiment.

In addition to instructional aspects, the teacher's role as a cognitive facilitator was also evident through reflection activities and feedback. Seventy-five percent of students reported that their teacher actively facilitated reflection by asking probing questions, such as those about reasons and cause-and-effect relationships, which encouraged students to think more deeply. Furthermore, constructive feedback from teachers (66.7%) helped students identify and correct errors during the practicum. These findings confirm that instructive, reflective, and formative teacher support are essential elements in optimizing the practicum experience and strengthening meaningful science learning.

Table 6. Table of Student Perceptions in Science Practicals

Dimensions of Perception	Subthemes / Factors	Number of Students (n=12)	Percentage (%)	Examples of Verbatim Quotations
Concept Understanding	Practicals make it easier to understand concepts	10	83,3	“I can relate theory to real experiments.”
	Practicum connects theory with everyday life	8	66,7	“The chemical reactions demonstrated in the experiment are similar to those I see in the kitchen.”
Active Involvement	Group discussion	9	75,0	“Studying in groups makes me more active in asking questions.”
	Practicum encourages personal initiative	8	66,7	“I tried the trial steps myself without fear of making mistakes.”

Relationship between Practicum and PBM	Practical work relevant to class material	8	66,7	“Practice makes learning more meaningful.”
	Practicals help understand difficult concepts	9	75,0	“An attempt to make complex concepts easy to understand.”
Teacher / Pedagogical Support	Clear instructions and teacher guidance	10	83,3	“The teacher always guides the experimental steps clearly.”
	Providing constructive feedback	8	66,7	“The teacher's feedback helped me correct my experimental errors.”
Obstacles / Constraints	Limited tools and materials	11	91,7	“The equipment is incomplete, so you have to bring your own from home.”
	Limited practicum time	8	66,7	“The practicum felt rushed because the time was short.”
	Difficulty understanding procedures	5	41,7	“The experimental steps are sometimes confusing; you have to ask the teacher again.”

Based on data in Table 6, students' perceptions of science practicums indicate a strong relationship between conceptual understanding, active engagement, and meaningful learning. In the conceptual understanding dimension, the majority of students (83.3%) reported that practicums made the material easier to understand because the concepts learned could be directly observed through experiments. Furthermore, more than half of the students (66.7%) were able to relate the practicum results to everyday phenomena, confirming the practicum's function in contextualizing abstract concepts into real, meaningful learning experiences.

DISCUSSION

In the dimension of active involvement and the relationship between practicum and teaching and learning, most students participated in group discussions (75.0%). They demonstrated personal initiative during the practicum (66.7%), such as independently undertaking experimental procedures without fear of error. Practicums were also perceived as relevant to the material taught in class (66.7%) and as effective in helping students understand complex concepts (75.0%). Teacher pedagogical support was the main strengthening factor, characterized by clear instructions and intensive guidance (83.3%) and the provision of constructive feedback (66.7%). However, students still faced significant obstacles, including limited tools and materials (91.7%) and limited time for practicum (66.7%). These obstacles indicate that optimizing meaningful learning through science practica depends not only on pedagogical strategies but also on adequate support from facilities and learning management systems.

The results of the study indicate that students construct meaningful learning as a process that extends beyond rote memorization, emphasizing conceptual understanding, real-world application, and empirical verification. Meaningful learning is perceived as contextual, applicable, and relevant to everyday life. Students consistently define “enjoyable” and “meaningful” learning as activities involving active participation, group collaboration, educational games, and hands-on practice, which significantly enhance cognitive and affective engagement. In the context of science learning,



practicum activities are a central element of meaningful learning (Sonata, 2019). Practicums are considered effective in bridging the gap between theoretical concepts and empirical reality, thereby helping students develop a deeper understanding. Students' affective responses to practicums are dominated by positive emotions, such as joy and enthusiasm, indicating high intrinsic motivation. In addition, students demonstrate adequate mastery of procedural skills, as evidenced by their ability to explain the stages of practicum activities systematically and to compile reports on their results, indicating the development of science process skills (Nur, 2021).

The most influential key factor in shaping positive perceptions of PBM is teacher guidance. Active teacher involvement in providing explicit, step-by-step, and supportive instruction creates a sense of security for students and minimizes confusion during practicum sessions. Furthermore, group collaboration strengthens social and contextual learning, consistent with the Pancasila Student Profile's emphasis on cooperation (gotong royong). Student interest in the practicum topic also plays a significant role in improving focus, motivation, and conceptual understanding. (N.K. Mardani et al., 2021); (Haq et al., 2020).

However, this study identified several technical and logistical barriers, including limited laboratory facilities, difficulty assembling equipment, and the need to bring their own laboratory materials. Despite these challenges, the majority of students reported improved conceptual understanding after the lab, demonstrating the lab's effectiveness in linking learning experiences to students' cognitive structures (Solihin & Dedah, 2022). Student Worksheets (LKS) were also perceived as instruments that support critical thinking, rather than simply as a means of providing answers.

CONCLUSION

Based on a qualitative exploration of students' perceptions at SMP Negeri 22 Jakarta, it can be concluded that science practicum activities are effectively and predominantly perceived as a means to achieve Meaningful Learning (PBM). Students' perception of PBM reflects a conceptual understanding applicable to real-life contexts, distinct from mere memorization. The primary determinant of practicum meaningfulness is the quality of teacher guidance and clear instructions. Active teacher involvement in scaffolding Cognitive skills successfully compensated for logistical and technical barriers, such as limited tools and materials, that students often had to prepare independently. Despite these logistical and technical barriers, they did not interfere with conceptual understanding, demonstrating the lab's success in facilitating Ausubel's substantive connections. This study implies that teachers need to design science practical activities that are contextual, interactive, and reflective to bridge students' learning experiences toward more meaningful learning (PMB).

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