

# Unveiling Insights: Students' Knowledge and Mastery of Microscopes at SMAN 1 Rasau

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Received: October 25, 2024

Revised: May 09, 2025

Accepted: June 25, 2025

Published: June 30, 2025

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DOI: [10.29303/jppipa.v11i6.9538](https://doi.org/10.29303/jppipa.v11i6.9538)

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**Abstract:** The utilization of the biology laboratory at SMA Negeri 1 Rasau has not been optimal, particularly in microscope practice, which plays a crucial role in developing students' observational skills. This study aims to explore students' knowledge of microscopes and their usage, with the goal of informing improvements in instructional strategies and laboratory management. A descriptive qualitative method was employed, using a questionnaire focused on four main aspects: the name of the microscope, its function, its parts, and how to operate it. The findings showed that although all students were able to correctly identify the microscope's name, their understanding of its function, structure, and operational procedures remained limited. These results highlight the need to improve both conceptual and practical comprehension through experiential, hands-on learning approaches. It is recommended that schools increase the frequency of laboratory practice, provide more structured guidance, and adapt instruction to address the areas where students show the most misunderstanding.

**Keywords:** Biology laboratory; Experiential learning; Microscope; Practical skills; Science education

## Introduction

A microscope is a fundamental tool in biology laboratory practice, enabling students to observe organisms and microscopic structures that are invisible to the naked eye, such as cellular components and microorganisms. Its use not only fosters technical skills in operating laboratory equipment but also sharpens students' observational abilities, scientific reasoning, and analytical thinking (Hilmi et al., 2017; Maier, 2014). The mastery of microscope operation is crucial for students to develop comprehensive scientific competencies.

Learning experiences in the laboratory must integrate both theoretical and practical elements to prevent misconceptions (Arsyad, 2020); Anoling et al., 2024). In this context, not only do teachers need to be effective collaborators, but students must also actively

participate in the activities and try things out for themselves (Ilvayani et al., 2023). Practical activities that involve the use of microscopes serve as a vital component of science education. As de Araujo et al. (2020) emphasize, one of the core objectives of practicum sessions is to ensure students are proficient in essential laboratory techniques, including the correct use of microscopes. Laboratory sessions are designed to teach students essential experimental methods and instrumentation skills to support conceptual understanding and scientific reasoning (Felder & Brent, 2016).

Effective microscope usage requires more than just operating the instrument—it also involves understanding the functions and mechanisms of its components. Drace et al. (2012) argue that students must not only demonstrate technical skills but also interpret observational data accurately by understanding how each part of the microscope contributes to image

## How to Cite:

Fitriani, E., Candramila, W., & Mardiyyaningsih, A. N. (2025). Unveiling Insights: Students' Knowledge and Mastery of Microscopes at SMAN 1 Rasau. *Jurnal Penelitian Pendidikan IPA*, 11(6), 893-901. <https://doi.org/10.29303/jppipa.v11i6.9538>

formation. Furthermore, Kaspul et al. (2022) highlight that successful practicum outcomes depend on students' comprehension of both the tool's structure and its function in scientific analysis.

Despite the recognized importance of microscopes in biology education, their effective utilization in schools remains a challenge. Continuous training and repeated exposure are essential to develop students' proficiency in tasks such as specimen preparation, focus adjustment, and accurate observation (Nurhayati, 2022). However, many educational institutions face limitations in optimizing laboratory use for active and meaningful student engagement (Henikusniati et al., 2018).

One such case is SMA Negeri 1 Rasau, located in Rasau Jaya District, Kubu Raya Regency, West Kalimantan. Founded in 1994 and accredited with an A-level status, the school has adopted the Merdeka Curriculum, which emphasizes independent and student-centered learning (Basic Education Data, 2024). The curriculum aims to nurture critical thinking, creativity, and practical skills across various disciplines, including science and technology.

Although the school is equipped with a laboratory, its utilization – especially for interactive and exploratory biology practicums – remains limited (Syamsu & Thariq, 2018). This underutilization poses a barrier to achieving the curriculum's goals of fostering analytical and scientific competencies through hands-on learning. Therefore, this study aims to investigate students' knowledge at SMA Negeri 1 Rasau regarding microscope components, functions, and operational techniques. The novelty of this research lies in its specific focus on assessing how students understand and apply microscopy in the context of laboratory learning – an

area that is often overlooked despite its foundational role in science education.

This research is important because improving students' understanding of microscopes can directly enhance the quality of practical biology instruction (Seprianingsih et al., 2017). It also offers valuable insights for refining teaching strategies, increasing laboratory engagement, and informing better laboratory management practices. Ultimately, the study seeks to bridge the gap between curriculum expectations and actual laboratory implementation, contributing to more effective science education at the secondary school level.

**Method**

This study adopted a descriptive qualitative approach to explore students' understanding and practical knowledge of microscope usage at SMA Negeri 1 Rasau. Data were collected through an open-ended essay questionnaire, which allowed for the collection of in-depth responses reflecting students' conceptual and operational knowledge. The research was conducted at the beginning of the odd semester in the 2024/2025 academic year, involving 33 students from Class XII MIA. This class was purposefully selected not only because of their prior exposure to laboratory activities involving microscopes in earlier grades, but also because their schedule and academic readiness aligned well with the study's aims. As the most advanced biology class at the school, Class XII MIA was considered representative of students who have received the full sequence of biology instruction.

**Table 1.** Sample Questionnaire Items and Expected Answers

Questions	Expected answer
1. What is the name of the tool below 2. What is the function of the tool? 3. Name the parts of the tool above!	Microscope To observe microscopic objects that cannot be seen with the naked eye.
4. How to operate the tool?	 <p>The microscope is placed on a flat plane, then provide the object to be observed. The coarse adjustment is loosened so that the placement of the object/ preparation on the microscope table can be done easily. Then, the revolver is turned to the smallest magnification and the lamp is turned on to start observing the object. The revolver is adjusted to select the desired magnification and continued by adjusting the coarse and fine focus.</p>

The research process involved three main phases: instrument preparation and validation, data collection, and data analysis. In the preparation phase, a four-question open-ended questionnaire was developed and validated by two lecturers from the Biology Education Study Program at Tanjungpura University. The content validity of the instrument was assessed based on five indicators: (1) alignment between questions and expected answers, (2) relevance of questions to research objectives, (3) alignment with targeted concepts, (4) clarity and accessibility of language, and (5) compliance with standard spelling rules. Validators reviewed the instrument using Yes/No ratings, which were used to determine whether revisions were necessary. Feedback from validators led to minor refinements in wording to improve clarity and precision. The finalized questionnaire was deemed valid after both validators agreed that all items met the stated indicators.

The questionnaire included four core questions (see Table 1), targeting students' knowledge of the microscope's name, function, parts, and operation. Students completed the paper-based questionnaire in class with a 20-minute time allocation, ensuring adequate time for reflection and written responses.

For data analysis, the study employed the thematic analysis method as described by Braun et al. (2006). This method was chosen for its effectiveness in identifying patterns, themes, and variations within qualitative data. Thematic analysis was conducted in six systematic stages (see Figure 1), beginning with familiarization through repeated reading of student responses. This was followed by initial coding, where meaningful phrases (e.g., "viewing small objects") were identified. Related codes were then grouped into broader themes during the theme construction stage. The themes were reviewed, refined, merged, or split to ensure coherence. In the theme definition stage, more nuanced interpretations were made—for instance, clarifying "small objects" as "bacteria" or "germs." Finally, the results were reported by presenting the frequencies of student responses in percentage form to highlight the variation in knowledge levels.

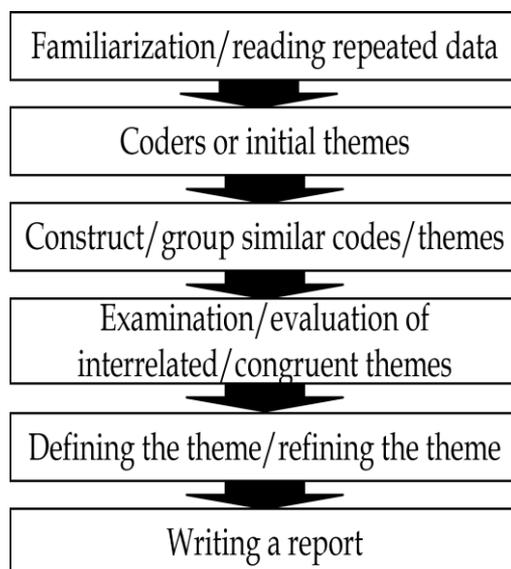


Figure 1. Stages of thematic analysis based on learner answer data referring to Braun et al. (2006)

## Result and Discussion

### Results

This study examined the knowledge of Grade XII MIA students at SMA Negeri 1 Rasau Jaya, Kubu Raya Regency, regarding microscopes and their usage. A total of 33 students participated in the study. Five open-ended questions were given through a questionnaire, covering the name of the tool, its function, the parts of the microscope, and how to operate it. The results of the data analysis are presented in terms of frequency and percentage to quantitatively demonstrate the students' level of understanding.

#### *Knowledge of the Tool's Name*

All students (100%, 33 out of 33) were able to correctly identify the tool as a "microscope," indicating a good level of basic knowledge regarding the name of the instrument.

#### *Understanding of the Microscope's Function*

Responses to the function of the microscope varied, indicating differing levels of understanding. There were six distinct answer categories. A total of 54.5% of students (18 out of 33) answered that the microscope is used to observe "objects or bacteria not visible to the naked eye." Another 33.3% of students (11 students) mentioned its function as observing small things such as germs or microorganisms but did not clarify the limitation of unaided human vision. The remaining responses consisted of 3% (1 student) giving a non-specific answer and 9.1% (3 students) providing irrelevant answers.

*Knowledge of Microscope Parts*

A total of 30.3% of students (10 out of 33) were able to correctly name parts of the microscope, such as the ocular lens and the microscope tube. In contrast, 39.4% (13 students) gave incorrect or irrelevant answers, and 30.3% (10 students) did not respond at all.

*Understanding of Microscope Usage*

Only 9.1% of students (3 students) were able to explain the complete operational steps, including

positioning the microscope, turning on the light source, and observing using the objective lens. Another 18.2% of students (6 students) gave partial answers covering only 1-2 correct steps, and another 18.2% gave incorrect procedural steps. A total of 12.1% (4 students) provided irrelevant answers, while 42.4% (14 students) did not respond at all.

**Table 2.** Students' Responses Regarding the Name, Function, Parts, and Operation of the Microscope

Question indicator	Variation of student answers	Number of students who answered
1. Correctly name the tools	Microscope	33
2. Mention the function of a microscope	To see objects or bacteria that are invisible to the eye directly	18
	To see small objects such as germs and others	11
	To see	1
	To examine a substance up close	1
	To determine the size of the object to be measured	1
3. Name the parts of the microscope	To measure	1
	Ocular lens	10
	Objective lens	2
Ocular lens	No Answer	21
	Microscope tube	10
Microscope tube	No answer	23
	Revolver	5
Revolver	Ocular lens	2
	No answer	26
Objective lens	Objective lens	6
	No answer	27
Microscope table	Microscope table	7
	No answer	26
Mirror	Mirror	9
	Lens	1
Microscope leg	No answer	23
	Microscope leg	4
Coarse focuser adjuster	No answer	29
	Coarse focuser adjuster	9
Fine focus adjuster	No answer	24
	Fine focus adjuster	9
Microscope handle	Coarse focus adjuster	1
	No answer	23
Clip/clamp	Microscope handle	7
	No answer	26
Inclination joint	Clip/clamp	5
	No answer	28
4. Mention how to operate the microscope	Inclination joint	6
	No answer	27
Write down how to operate the microscope, from placing it on a flat plane to observing the object under the objective lens due to the reflection of light from the mirror.	Place the light microscope and preparation glass on a flat surface. Adjust the objective lens's magnification to the lowest point, make sure the objective lens is on the axis of observation, and adjust the microscope mirror so that the light can reflect onto the object of study. Hands hold the microscope, adjust the lens size, place the glass, turn on the microscope light, adjust the	3

Question indicator	Variation of student answers	Number of students who answered
Write the operation method incompletely or only 1-2 steps.	reflector's position, adjust the aperture, and place the preparation.	6
	Rotated, placed leaves, for example, on a microscope and then zoomed and looked at it closely	
	Carefully place the light microscope on a flat surface so that the light can reflect onto the object.	
	Placing the object on one part of the microscope brings the eye close to the lens.	
	Place the microscope in the direction of the light, placing the preparation glass on a flat surface.	
Write down 1-2 stages of operation but not correct/unrelated.	Place the material to be viewed, clamp the preparation on it, and adjust the microscope lens.	6
	By sliding	
	Place the microscope on a flat surface and arrange the mirror so the light reflects off it.	
Write answers that are not related to the method of operation.	Bringing the eye closer to the microscope	4
	Place the object on the viewing mirror.	
	Zoomed in	
Don't know	Place the tool above the light.	3
	Shapes the object's shadow to make it visible	
No answer	Don't know	11
	No answer	

The following table presents the distribution of frequencies and percentages for each category of student answers across the indicators.

**Table 3.** Students' Response to Microscope Knowledge Indicators

Indicator	Response Category	Frequency	Percentage
Tool name Microscope function	Correct	33	100%
	Accurate	18	54.5%
	Partially accurate	11	33.3%
	Nonspecific/irrelevant	4	12.2%
Microscope parts	Correct	10	30.3%
	Incorrect/irrelevant	13	39.4%
	No answer	10	30.3%
Microscope usage	Complete	3	9.1%
	Partial	6	18.2%
	Incorrect	6	18.2%
	Irrelevant	4	12.1%
	No answer	14	42.4%

*Discussion*

This study examined students' understanding of microscopes in terms of their ability to (1) identify the instrument, (2) describe its function, (3) recognize its components, and (4) explain its usage. While the results showed high accuracy in identifying the microscope by name, students exhibited progressively lower levels of understanding when asked about its function, parts, and operational procedures. Students' recognition of the term "microscope" may have developed over an extended period. At the elementary education level, the use of microscopes is not formally included in science instruction under either the 2013 Curriculum (K13) or

the Merdeka Curriculum. However, beginning in the first and second semesters of junior high school, students are introduced to topics such as microscopic organisms and optical instruments, through which they gradually gain exposure to the concept of the microscope, including its components and underlying working principles (Widodo et al., 2017).

*Understanding of the Microscope's Function*

A total of 33 students (100%) correctly identified the instrument as a "microscope," reflecting strong baseline recognition. However, when asked about its function, only 18 students (54.5%) provided scientifically accurate responses—describing its role in viewing microscopic objects not visible to the naked eye. Eleven students (33.3%) gave partially correct answers, such as stating that it is used to see "germs" or "small things," without emphasizing the necessity of magnification. The remaining 4 students (12.2%) gave unclear or unrelated answers.

These findings suggest that although students grasp the general concept that microscopes help with viewing small objects, many lack depth in understanding the distinction between microscopic and merely small objects. This is consistent with Ziraluo (2021), who notes that limited practicum opportunities can lead to shallow conceptual knowledge. The fact that some students associate microscopes with visible "germs" or small objects might also stem from educational media or simplified classroom explanations, where complex concepts are reduced to easily relatable terms. In another study, Utami et al. (2024) stated that

students tend to understand large objects easily because they can be seen directly; however, their understanding of small objects declines significantly once the objects become too small to be seen without the aid of an instrument.

On the other hand, students who gave unrelated responses likely had little to no experience handling the tool, further highlighting the gap between theoretical exposure and practical engagement (Gladya et al., 2013). This gap is not uncommon in science education, particularly in contexts where laboratory access is limited or where instruction emphasizes theoretical knowledge over procedural competence. As noted by Eidesen et al. (2023), students who are unfamiliar with basic operational steps—such as adjusting illumination, rotating objective lenses, or focusing—often struggle to articulate the functional purpose of the microscope beyond simplistic descriptions like “to see small things.” This suggests that conceptual understanding of instrument function is closely tied to procedural fluency, and that practical experience reinforces the ability to connect structure with purpose.

#### *Knowledge of Microscope Components*

When asked to identify microscope parts, only 10 students (30.3%) gave accurate answers, such as naming the ocular lens, stage, or objective lens. Thirteen students (39.4%) provided irrelevant or incorrect parts—such as naming non-existent components or confusing the names of parts—while the remaining 10 students (30.3%) did not respond.

The variability in answers may be attributed to both a lack of theoretical grounding and insufficient practical exposure. Mursali et al. (2023) emphasize the role of repeated, hands-on interaction in building familiarity with laboratory equipment. Additionally, certain incorrect answers may be due to visual or lexical confusion; for example, students may confuse the coarse adjustment knob with the fine focus due to their physical proximity, or misunderstand terms like “mirror” and “condenser” because both relate to light manipulation. These issues highlight the need for targeted instructional support and terminology clarification during practicum sessions.

Without detailed explanations and hands-on training, students may struggle to differentiate between the essential components of the microscope. This difficulty often stems from the physical similarities and closely related functions of certain parts, such as the coarse and fine adjustment knobs, or the mirror and condenser, both of which are involved in light manipulation. Such confusion is frequently exacerbated by limited direct experience with the tool, leading students to rely solely on memorized terminology without connecting it to actual function (Fajarini &

Peniati, 2020). Furthermore, Nurhasanah et al. (2024) demonstrated that students' conceptual understanding of the microscope improved significantly after participating in step-by-step demonstrations and repeated practice sessions, as found for other laboratory tools (Side et al., 2024). Therefore, microscope instruction should not rely solely on theoretical explanations but should integrate visual demonstrations, simulated practice, and direct interaction with the instrument to help students develop a comprehensive conceptual and procedural understanding of the microscope and its functions.

#### *Knowledge of Microscope Operation*

Only 3 students (9.1%) were able to describe the microscope's usage procedures completely, including correct placement, illumination, and focusing. Another 6 students (18.2%) provided partial responses that included only 1–2 correct steps, and 6 students (18.2%) gave incorrect operational steps. Four students (12.1%) submitted irrelevant answers, while 14 (42.4%) left the question blank.

This widespread lack of operational understanding suggests weak psychomotor skills related to laboratory work. Kusumawati (2016) and Mistry et al. (2020) argue that ineffective microscope use—such as failure to adjust lighting or focus properly—can hinder meaningful observations. Shoemaker (2010) adds that low self-confidence in equipment handling also impedes laboratory learning outcomes. Our findings affirm these concerns; the high rate of non-responses and incorrect procedures underlines the urgent need for more structured and hands-on microscope training.

Inadequate operational understanding may also stem from instructional gaps, where laboratory tools are introduced only superficially, without sufficient emphasis on skill progression. Shana et al. (2020) emphasize that practical science work significantly improves students' academic achievement and skill acquisition when integrated as an essential part of science teaching. Without repeated and scaffolded engagement, students tend to compartmentalize theory and practice, resulting in fragmented learning and limited transfer of skills (Taber & Tsaparlis, 2008; Fadzil & Saat, 2017). Furthermore, as shown by Eidesen et al. (2023), direct performance assessments and certification of practical competencies, including microscope operation, significantly improve students' confidence and skills, especially when peer feedback and formative assessment are integrated.

The observed data suggest both cognitive and pedagogical disconnects. When procedural fluency is assumed rather than explicitly taught, students may guess or avoid tasks, as reflected by the high percentage (42.4%) of blank responses, indicating possible anxiety

or unfamiliarity (Archer et al., 2015). Consistent with Black et al. (2009), and Black et al. (2018) findings on formative assessment, feedback-rich and scaffolded practical instruction enables students to build competence and self-efficacy. To address this, educators should implement deliberate instructional strategies, such as guided demonstrations, structured practice sessions, and supportive learning environments that encourage experimentation without fear of failure (Sadi & Cakiroglu, 2011; Holmegaard et al., 2014; Morris, 2025). Such approaches foster deeper conceptual and procedural mastery of microscope use essential for scientific inquiry, and they can be effective even when implemented through virtual laboratories (Anjarsari et al., 2023).

The pattern across the three indicators—function, parts, and usage—demonstrates a clear decline in student mastery as task complexity increases. This trend emphasizes the importance of bridging theoretical knowledge with practical application. As Abdullah et al. (2014) note, biology education that emphasizes psychomotor skill development is essential for fostering deeper engagement and proficiency in scientific inquiry. Without integrated, hands-on instruction, students are prone to misconceptions and mechanical use of tools without real understanding (Millar & Abrahams, 2009; Holbrook & Rannikmäe, 2007). Therefore, effective biology education must provide continuous, guided opportunities to develop both conceptual and operational competence, ensuring that students can transition from knowing about a tool to confidently using it as part of the scientific process.

Variations in students' understanding are likely influenced by inconsistent practicum exposure and unequal opportunities for hands-on interaction with laboratory tools as found in several schools (Darmayanti et al., 2023; Nabila et al., 2024; Anjarsari et al., 2023). Students who engage in regular, structured lab activities tend to demonstrate better understanding and greater technical accuracy. Thus, teachers should incorporate more skill-oriented, participatory lab experiences that ensure every student interacts directly with microscopes. Direct experiential learning enhances conceptual retention and operational skill development (Pherson-Geyser et al., 2020; Apeadido et al., 2024). In addition, practical work aims to develop students' hands-on skills and procedural mastery necessary for effective scientific experimentation and learning (Bennett et al., 2017).

## Conclusion

This study found that while students were generally able to identify the microscope by name, their understanding of its functions, structural components,

and operational procedures was significantly limited especially in terms of function and correct usage. These findings highlight a critical gap in both conceptual and practical knowledge of microscope use. To address this, it is recommended that biology instruction integrate more frequent, structured, and hands-on laboratory sessions focused on the specific areas where students show the greatest difficulty. Future research may explore the effectiveness of different teaching strategies in improving students' microscope skills or compare learning outcomes across different grade levels.

## Acknowledgments

The authors thank the principal, teachers, and all students at SMAN 1 Rasau, Kubu Raya Regency, for participating in this research. This study is part of the broader research initiative undertaken by the second author, which aims to inventory and analyze the profiles of biology laboratories in various public high schools within Kubu Raya Regency as a preliminary step toward enhancing these facilities.

## Author Contributions

Conceptualization, E. F. and W. C.; methodology, all authors; investigation and sampling, E. F. and W. C.; data analysis, all authors; writing—original draft preparation, all authors; writing—review and editing, E. F. and W. C. All authors contributed equally and have read and agreed to the published version of the manuscript.

## Funding

This research is part of a broader initiative led by the second author, aimed at inventorying and analyzing the profiles of biology laboratories across various public high schools in Kubu Raya Regency, serving as a foundational step toward their improvement.

## Conflicts of Interest

The authors declare no conflict of interest.

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