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# The Effect of Practicum-Integrated Discovery Learning Model on Students' Procedural Knowledge of Microscope Use and Cell Structure Observation

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**Abstract**

Having procedural knowledge empowers students and helps them connect theory and practice in biology education. Encouraging pupils to learn procedural knowledge helps them acquire academic talents and practical life skills. In fact, many studies show that students' procedural knowledge is still low, especially regarding the use of microscopes and cell observation. This study aims to discover how the Discovery Learning model, combined with practicum, affects students' procedural understanding of using microscopes and seeing cell structures. A pretest-posttest control group design was employed in this quantitative quasi-experimental study. The pupils of Class XI at one of the senior high schools in Pandeglang, Banten comprised the research population. Seventy-four students were chosen at random to make up the research sample. Two groups—the experimental and control class groups—were created from the research sample. Students in the control class utilized the Discovery learning model without practicum activities, while students in the experimental class used the Discovery learning model combined with practicum activities. According to the findings, students in the experimental class outperformed those in the control class regarding their average post-test score on procedural knowledge. Additionally, pupils in the experimental class had a greater improvement in procedural knowledge. Students' comprehension of scientific topics is strengthened by combining discovery learning with practicum. Additionally, students become more involved in the learning process, which boosts their procedural knowledge. Students in the experimental class were more actively engaging in each activity stage, according to the observation data from the practicum. This result demonstrates how students' procedural knowledge and learning outcomes are enhanced when discovery learning and practicum are combined. Therefore, in order to enhance students' procedural understanding, teachers had to increase the frequency of practicums.

Keywords: Procedural knowledge, Practicum method, Discovery Learning, Microscope, Biology

## INTRODUCTION

Biology is a branch of science that high school students should learn. Biology lessons play an important role in forming student competencies relevant to real life and the development of scientific knowledge. Biology provides a deep understanding of living things, ecosystems, and biological phenomena around students. As a fundamental subject, biology is also the basis for various fields of study and professions, such as medicine, biotechnology, pharmacy, and agriculture.

Learning biology requires an approach that focuses on theory and hands-on experience. The constructivism approach is the most appropriate approach to the characteristics of Biology learning. The basic principle of the constructivism approach is that students must be directly involved in the learning process to build their knowledge. The constructivist approach encourages students to understand the relationship between learning concepts and the problems they encounter in everyday life (Pujiningsih *et al.,* 2022). The Discovery learning model is one of the learning models of this approach.

The discovery learning model integrated with the practicum method, empowers students knowledge. It allows them to receive, try, train, develop, and discover for themselves (Pujiningsih *et al.,* 2022). Biology practicum is an application of the theories or concepts learned to solve various biological problems through several experiments. Practicum is an important component in science education, especially biology, because it involves students in direct exploration, developing scientific skills, and strengthening their understanding of concepts. Practicum has been proven to be an effective learning method in facilitating a thorough understanding in students (Saleh & Andis, 2024).

Practical activities help students understand complex, challenging, and abstract Biology concepts better. Practical activities provide opportunities for students to engage directly in the learning process through observation, data collection, and analysis, all of which strengthen science process skills (Ulfa, 2016). Practical activities help students apply theory in a practical (cognitive) context. Practicum can also develop independence in planning activities (effective) and improve students' skills in using specialized tools or instruments (Saleh & Andis, 2024).. Practicum also helps students develop critical and analytical thinking skills. This is important to prepare students for the challenges of the modern world that demand complex and adaptive thinking skills. Practical activities, including practicum, have been shown to significantly improve students' procedural knowledge (Alimuddin, 2022).

Practicing using a microscope and observing cell structures are examples of important practicums in schools. The practicum of using a microscope provides an opportunity for students to understand the important role and workings of a microscope. The microscope allows students to observe microorganisms or the smallest structures of living things (Kara, 2018). Using microscopes in practicum allows students to directly observe cells and their components, thus providing a more concrete learning experience. Observation of cell structure is also important because it helps students understand it through hands-on lab activities. In biology, learning, cell structure, and function are often difficult for students to understand deeply if only taught through lectures and theory.

The research conducted by Mirna & Annisa (2025) showed that practicum methods that provide hands-on learning experiences effectively improve students' science process skills. This is supported by the research findings of Afifah *et al.* (2021), which show that practicum helps students more easily understand science concepts. Practicum can help students accelerate learning, gain a deeper understanding of learning materials, and accelerate knowledge acquisition (Nuai & Nurkamiden, 2022). Practicum also affects students' procedural knowledge and learning outcomes (Alimuddin, 2022). A well-structured practicum not only serves to improve students' understanding of biological material, but also improves their overall scientific skills, such as critical thinking skills, observation skills, and the ability to formulate hypotheses (Ulfa, 2016). In addition, with intensive supervision and guidance from teachers, students can learn to use microscopes more effectively and efficiently (Killpack *et al.,* 2020). This practicum method makes students more active, motivated, and eager to learn (Nisa, 2017). The microscope based on the STEM approach can also train and hone students' creative thinking skills (Samsuar *et al.,* 2024).

The literature review results show that applying the Discovery Learning model integrated with a simple practicum can be an alternative to improve students' science process skills (Hikmahtika, 2024). However, research on how Discovery Learning combined with practicum affects students' procedural knowledge has been scarce. Understanding the significance of combining practicum experiences with the Discovery Learning paradigm is crucial for enhancing students' procedural knowledge. The impact of the practicum-integrated Discovery Learning model on students' procedural knowledge regarding the use of microscopes and the observation of cell structures must thus be investigated. This research's long-term objective is to help schools create more contextualized learning programs and enhance laboratory practicum quality to strengthen students' procedural knowledge.

## METHOD

The research was conducted using a quantitative research approach with a pretest-posttest control group design in a quasi-experimental method (Table 1). Class XI students at one of senior high schools at Pandeglang, Banten, comprised the study's population. There were 74 pupils in the research sample, which was randomly sampling. Students in the control and experimental classes made up the two groups into which the study sample was split. Thirty-five students were in the control group, and 39 were in the experimental group. While the control group employed the discovery learning model without including practicum activities, the experimental group employed the model in conjunction with practicum activities.

Table 1. Research Design

| ***Group*** | ***Pre-test ($Y_1$)*** | ***Treatment*** | ***Post-test ($Y_2$)*** |
|---|---|---|---|
| XI-2 (Experiment) | $Y_1$ | X-E (Discovery learning with practicum) | $Y_2$ |
| XI-3 (Control) | $Y_3$ | X-C (Discovery learning without practicum) | $Y_4$ |

Description:
$Y_1$: pre-test score of students of Experiment Class
$Y_2$: post-test score of students of Experiment Class
$Y_3$: pre-test score of students of control Class
$Y_4$: post-test score of students of control Class

**Research instrument**

The research instrument used was a written test question to measure students' procedural knowledge. The ten essay questions on the exam assessed procedural knowledge, namely knowledge of abilities in a given subject, knowledge of techniques and procedures in a particular field, and knowledge of the criteria for deciding when to employ the proper process (Table 2). An assessment specialist verified the exam questions, which were only tested on students before usage. With a dependability of 0.81, falling into the high category, the results demonstrated that this instrument was deemed legitimate.

Table 2. Grids of Procedural Knowledge Test Instruments

| Indicator of Procedural Knowledge | Aspects of Procedural Knowledge | Number of Questions |
|---|---|---|
| Identifying the parts of the microscope and their functions | (1) | 2 |
| Operating the microscope with a clear focus on the cell | (2) | 2 |
| Performing proper cutting techniques to produce thin sections | (1) | 2 |
| Determining the appropriate dye for cell observation | (3) | 2 |
| Performing staining techniques to clarify cell | (2) | 2 |
| *Total Number of Questions* | | 10 |

Description:
Aspects of Procedural Knowledge according to Anderson & Krathwohl (2010):
(1) Knowledge of skills in a particular field
(2) Knowledge of techniques and methods in a particular field
(3) Knowledge of criteria for determining when to use appropriate procedures.

The instrument used to determine the implementation of the discovery learning learning model integrated with practicum activities is an observation sheet. This instrument uses a rating scale. Observations were made of five groups of students in the experimental and control classes during learning at meetings 1 and 2. The observer put a checkmark (√) in the available column during the observation. A check mark (√) in the “Yes” column indicates that the learning process implemented was by the discovery learning syntax and that the performance on the assessed aspects was appropriate. Conversely, a tick mark (√) in the “No” column indicates that the learning process was not by the discovery learning syntax and that the performance on that aspect was not by the set criteria or did not appear.

**Data Analysis**

The procedural knowledge assessment rubric assessed students' answers to the procedural knowledge test questions. The data obtained were then analyzed descriptively to determine the average score and distribution of students' procedural knowledge categories. Furthermore, a prerequisite test was conducted to determine the distribution and homogenity of the research data. Finally, a t-test was conducted to determine the effect of the Discovery Learning model integrated with practicum on students' procedural knowledge. This analysis was conducted using SPSS program. Observation data on implementing the Discovery Learning model syntax was described qualitatively as supporting data.

**RESULTS AND DISCUSSION**

The average pretest score of procedural knowledge of experimental class students through applying the practicum-integrated Discovery Learning model is almost the same as that of control class students. Control class students had an average pretest score of 70, with a standard deviation of 6.32, while the experimental group had an average pretest score of 72.50, with a standard deviation of 5.77 (Table 3). This data shows that the initial knowledge of control and experimental class students is homogeneous before treatment. This homogeneity is important to maintain the validity of the research, that differences in student learning outcomes that occur after being given treatment can be the influence of differences in learning methods used, not other factors. The homogenity test is important to ensure that the statistical analysis has a strong basis, accurate results, and valid conclusions (Husaeni *et al.,* 2025).

Table 3. Data of Students Procedural Knowledge on Pretest and Posttest Results

| Students' Procedural Knowledge Score | Control Class (XI-3) | | Experiment Class (XI-2) | |
|---|---|---|---|---|
| | Pre-test Score | Post-test Score | Pre-test Score | Post-test Score |
| Minimum Score | 60 | 80 | 65 | 85 |
| Maximum Score | 80 | 95 | 80 | 98 |
| Average Score (*Mean*) | 70.00 | 87.50 | 72.50 | 91.50 |
| Standard Deviation (SD) | 6.32 | 5.30 | 5.77 | 4.79 |

The average post-test score of procedural knowledge of experimental class students is higher than that of control class students. The average post-test score of procedural knowledge of control class students was 87.50, and the standard deviation was 5.30. The experimental class students had an average score of 91.50 and a standard deviation 4.79 (Table 3). This finding shows that the procedural knowledge of experimental class students increased more than that of control class students. This increase caused the post-test scores of procedural knowledge of experimental class students to be higher than those of control class.

The results showed that the average student's procedural knowledge score increased from the pretest to the posttest in the control class and varied in each skill indicator. The highest increase in procedural knowledge was found in the indicator "Perform proper cutting techniques to produce thin sections" by 19.6%, from 67.8% in the pretest to 87.4% in the posttest (Figure 1). This finding shows that students more easily understand conceptual material related to “perform proper cutting techniques to produce thin sections”. This concept can be understood because students can read literature that explains the steps of making preparations. The results of this study contradict the findings of research on the problem of Practicum of Life Organization Material, which shows that only a few students were proficient in making preparations. In contrast, other students could not prepare well (Lestari *et al.,* 2017). In addition, other research shows that hands-on training improves students' understanding and technical skills, such as cutting and coloring techniques. However, these complex technical skills require intensive practice and adequate facilities to achieve optimal results (Eidesen *et al.,* 2023).

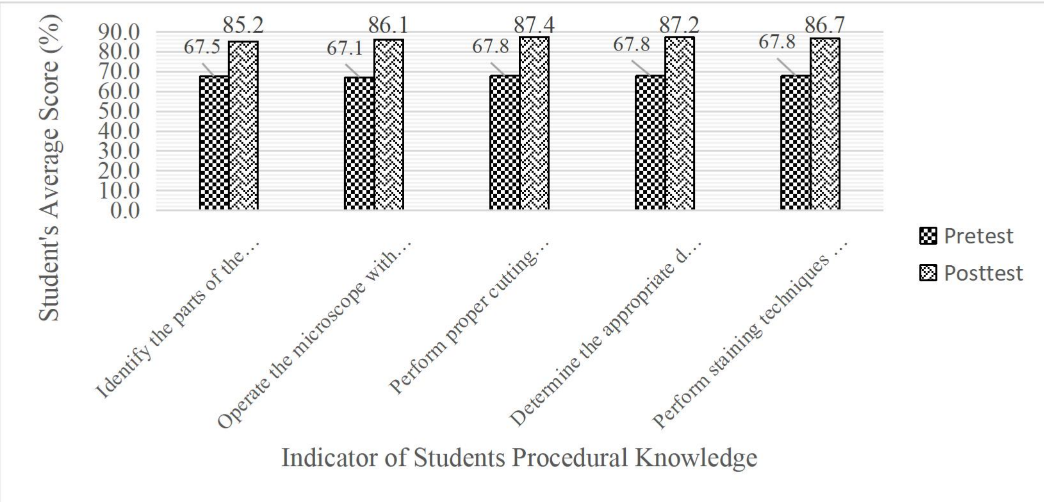


Figure 1. The average score of control class students on each indicator of procedural knowledge

The lowest increase in procedural knowledge in the control class students was found in technical skill indicators, namely " Identify the parts of the microscope and their functions," namely 17.7.9%. This finding shows that students do not understand the parts of the microscope and their functions. This is because learning is only carried out with the Discovery learning model. During learning, students only find out about the parts of the microscope and their functions through the internet without direct practicum through the use of a microscope. As a result, students' acquisition of microscope parts and their functions did not improve well.The results of this study are different from the findings of research on Biology education students, which show that most students already know the parts and functions of microscopes and their maintenance, but some others are still in the sufficient and less knowledgeable categories (Mardani *et al.,* 2024).

Students' low improvement in procedural knowledge of identifying microscope parts and their functions is caused by many factors, including the teacher's limited information and knowledge regarding the parts and functions of the microscope. The teacher's ability to manage practicum or laboratory affects the implementation of practicum, which ultimately affects students' knowledge (Lestari *et al.,* 2017). Most teachers also do not know how to maintain and store microscopes in accordance with operational standards (SOP), so they rarely carry out practicums, especially on microscope operations (Mardani *et al.,* 2024).

Students of the experimental class who used the practicum-integrated Discovery learning model showed a higher increase in procedural knowledge than the control class students. This finding is in line with the research results, showing that the practicum-integrated Discovery learning model positively affects students' procedural knowledge (Alimuddin, 2022). Improved procedural knowledge can occur because the Discovery learning model integrated with practicum provides opportunities for students to learn independently and build their own knowledge. Before the practicum, students read the procedures or practicum steps, starting from the selection of tools and materials used in the experiment and the practicum work steps. The syntax of the discovery learning model encourages students to gain a deeper understanding of the learning material because they memorize concepts and find them themselves (Widyastuti *et al*., 2024). The practicum-integrated Discovery learning model helps students understand concepts, meanings, and relationships between concepts through an intuitive process to conclude. Discovery occurs when students are directly involved in learning by using their mental processes to discover concepts and principles (Khasinah, 2021).

The procedural knowledge of experimental class students increased in all indicators. The highest increase was found in the indicator "Perform coloring techniques to clarify cell structure," which amounted to 32.1% from the pretest (66.5%) to 98.1% at the post-test (Figure 2). This finding shows that the Discovery learning model integrated with practicum, a form of direct learning, can improve students' procedural knowledge, especially related to skills requiring more intensive technical practice. Through practicum activities, students perform tissue staining to see the cell structure, thus increasing their procedural knowledge.

The lowest increase in students' procedural knowledge was found in the indicator "Performing the right cutting technique to produce thin pieces," which only amounted to 14.7% from the pretest score (61.4%) to 76.1 in the post-test (Figure 2). This finding aligns with research on junior high school students in Enggal District, which showed that only a few students were proficient in making preparations. In contrast, other students could not prepare well (Lestari *et al*., 2017).

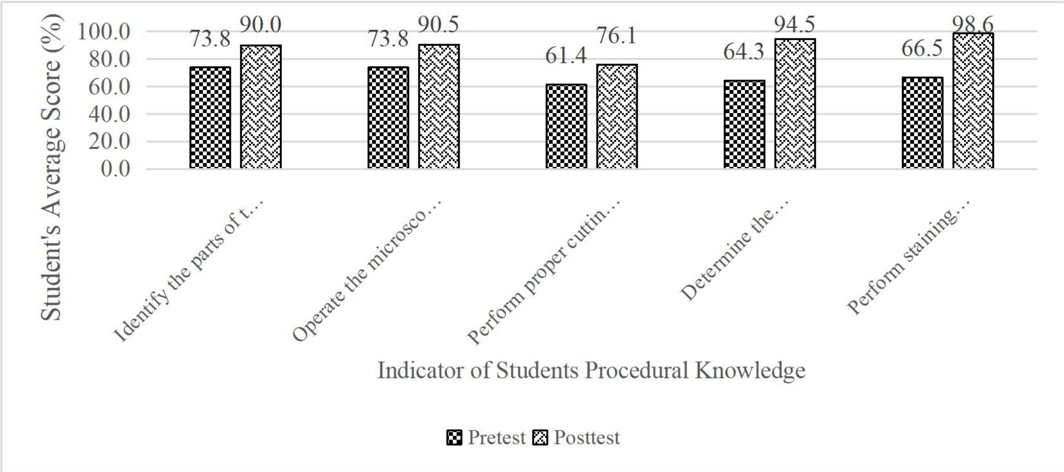


**Figure 2.** Average scores of experimental class students on each indicator of procedural knowledge.

The low increase in procedural knowledge on this indicator is likely due to the difficulty level of the technical skills of cutting, which requires more practice and better mastery of the tools. In addition, limited time or supporting facilities can also affect students' knowledge in this aspect. Other research results show that hands-on training improves students' understanding and technical skills, such as cutting and staining techniques. However, these complex technical skills require intensive practice and adequate facilities to achieve optimal results (Eidesen *et al*., 2023).

**Hypothesis Testing.**

The procedural knowledge data of students in the control and experimental classes were homogenous and regularly distributed following the data analysis requirement test. Thus, the t-test was used to continue the hypothesis testing. The findings demonstrated that students' procedural knowledge was significantly impacted by using the Discovery learning approach in conjunction with practicum. The t-table, which was 2.00, was less significant than the post-test findings (Table 4).

Table 4. Hypothesis Test Results.

| | Average Pretest Score | | Average Posttest Score | |
|---|---|---|---|---|
| Group | Control | Experiment | Control | Experiment |
| N | 30 | 30 | 30 | 30 |
| $\bar{X}$ | 70,00 | 72,50 | 87,50 | 91,50 |
| $S^2$ | 39,94 | 33,30 | 22,94 | 28,10 |
| $t_{count}$ | -1,25 | | 2,45 | |
| $t_{table}$ | 2,00 | | 2,00 | |
| Conclusion | No different | | different | |

According to the findings, the average pretest and posttest scores of the students in the experimental and control classes differed significantly. Students in the experimental class had a greater rise in average pretest to posttest scores than students in the control class. Compared to Discovery Learning without practicum integration, the experimental class's greater rise demonstrated that the discovery model significantly affects students' procedural knowledge. Per the original research criteria, the average scores of the experimental (72.50) and control (70.00) groups at the pretest stage were comparatively uniform. Students in the experimental class achieved an average post-test score of 91.50 after receiving instruction using a practicum-integrated Discovery learning paradigm, compared to 87.50 for students in the control class. The t-test findings, which show that the difference in outcomes is not random but rather impacted by the therapy, corroborate this substantial difference with a t-count value of 2.45 that is higher than the t-table of 2.00.

The increase in procedural knowledge of experimental class students is higher because the practicum-integrated Discovery Learning model allows students to more actively explore concepts, apply theories, and practice scientific procedures. This involvement is reflected in various aspects of skills, such as identification of microscope parts, operating with a clear focus, cutting techniques, and cell staining, which increased significantly. These results align with the findings of other studies showing that practicum activities improve students' analysis and observation skills because Discovery Learning encourages students to discover concepts independently (Khasinah, 2021). Thus, this comparison of pretest-posttest scores reinforces the finding that the practicum-integrated Discovery Learning model significantly impacts students' procedural knowledge.

The findings of this study support constructivist theory, specifically that active student involvement in the learning process (through discovery learning and practical work) significantly improves procedural knowledge. The combination of discovery learning and practical work reinforces the assumption that meaningful learning occurs when students construct their knowledge through direct experience and exploration. The study's results also confirm that discovery learning integrated with practical work can enhance the effectiveness of this model, particularly in the context of biology learning, which requires procedural skills rather than just conceptual knowledge. Teacher can use this study's results to design more contextual and laboratory-based learning programs. These programs can improve students' procedural knowledge and prepare them for real-world challenges that require practical skills and critical thinking. This improvement can be achieved by providing adequate laboratory facilities to ensure that practical work runs optimally. Therefore, school leaders need to improve facilities and laboratory facilities that support the implementation of practical work.

The limitation of this study is the observational data were collected over only two meetings, which may not fully capture the range of student engagement or procedural development throughout a longer instructional period. The procedural knowledge test focused on specific skills related to microscope use and cell structure observation, potentially overlooking broader aspects of procedural knowledge or other science process skills. Future studies should involve larger and more diverse student populations from multiple schools and regions to enhance the generalizability of results. Further research could investigate the effectiveness of the integrated discovery learning model in other subjects or fields of study, as well as at different educational levels, to determine if these findings can be generalized. Further studies also can explore factors that influence the success of integrating discovery learning and practical work, such as the availability of facilities, teacher readiness, and student characteristics. Future research could compare the effectiveness of discovery learning integrated with practicum to other active learning models, such as inquiry-based or problem-based learning. Further studies should investigate how teacher readiness, instructional quality, and laboratory facility adequacy influence the success of practicum-integrated discovery learning

## CONCLUSION

This study demonstrates that integrating the Discovery Learning model with practical activities significantly enhances students' procedural knowledge, particularly in the use of microscopes and the observation of cell structures. The results show that students who learned using the Discovery Learning model, integrated with practical activities, achieved higher post-test scores in procedural knowledge and experienced greater improvement compared to students who only followed the Discovery Learning model without practical activities. The integration of laboratory activities in learning not only strengthens theoretical understanding of concepts but also encourages active student engagement, develops scientific process skills, and fosters critical and analytical thinking abilities. These findings underscore the importance of hands-on laboratory experiences as an integral part of biology education, bridging the gap between theory and real-world practice. Therefore, teachers and schools are advised to increase the frequency and quality of laboratory practice implementation in biology learning, as well as develop more contextual and laboratory-based learning programs to strengthen students' procedural knowledge. This study also opens opportunities for further research to test the effectiveness of similar models on different subjects and educational levels, as well as explore factors influencing the success of integrating Discovery Learning and laboratory practice.

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