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Students' Practical Skills in Plant Tissue Laboratory Work Using Procedural Videos

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ABSTRAK

Penelitian ini bertujuan untuk mengetahui keterampilan praktikum peserta didik yang menggunakan video prosedur praktikum Biologi pada materi jaringan tumbuhan, keterampilan praktikum peserta didik yang mengikuti pembelajaran tanpa video prosedur, serta perbedaan keterampilan praktikum antara kedua kelompok. Penelitian menggunakan pendekatan kuantitatif dengan metode eksperimen semu dan desain posttest-only nonequivalent control group. Sampel penelitian berjumlah 60 peserta didik kelas XI MIPA di SMAN 1 Jeneponto yang terdiri atas 30 peserta didik kelompok eksperimen dan 30 peserta didik kelompok kontrol. Data dikumpulkan melalui observasi keterampilan praktikum dan dokumentasi. Analisis data menggunakan statistik deskriptif, uji Shapiro-Wilk, dan uji Mann-Whitney U. Kelompok eksperimen memperoleh rata-rata skor keterampilan praktikum sebesar 39,70 dengan standar deviasi 0,596, sedangkan kelompok kontrol memperoleh rata-rata 28,37 dengan standar deviasi 4,382. Hasil uji Mann-Whitney U menunjukkan nilai U sebesar 0,000, Z sebesar -6,857, dan nilai signifikansi <0,001. Hasil tersebut menunjukkan adanya perbedaan yang signifikan secara statistik pada keterampilan praktikum antara kelompok eksperimen dan kelompok kontrol. Kelompok eksperimen memperoleh capaian keterampilan praktikum yang lebih tinggi dibandingkan kelompok kontrol.

ABSTRACT:

This study aimed to determine the practical skills of students who used Biology practical procedure videos on plant tissue material, the practical skills of students who learned without procedure videos, and the difference in practical skills between the two groups. This study employed a quantitative approach with a quasi-experimental method and a posttest-only nonequivalent control group design. The sample consisted of 60 eleventh-grade students at Public Senior High School 1 Jeneponto, with 30 students assigned to the experimental group and 30 students to the control group. Data were collected through practical skills observation and documentation. Data analysis involved descriptive statistics, the Shapiro-Wilk test, and the Mann-Whitney U test. The experimental group obtained a mean practical skills score of 39.70 with a standard deviation of 0.596, while the control group obtained a mean score of 28.37 with a standard deviation of 4.382. The Mann-Whitney U test resulted in U = 0.000, Z = -6.857, and p < 0.001. The results indicate a statistically significant difference in students' practical skills between the experimental and control groups. The experimental group achieved higher practical skills scores than the control group.

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Introduction

Biology education involves not only the acquisition of conceptual knowledge but also learning activities that provide students with direct learning experiences (Ramadhan et al., 2025). Laboratory practical work is one such activity, enabling students to observe biological specimens, use laboratory equipment, perform measurements, record observations, and draw conclusions based on empirical data. These activities are closely associated with the development of science process skills, which are essential in biology education (Acarli & Derviş̧oğlu, 2021). Laboratory activities can facilitate the development of science process skills, while studies by Farida et al. (2022) and Ramadani et al. (2022) have demonstrated that practical work can be used to strengthen students' science process skills.

Plant tissue is particularly relevant to laboratory-based learning because the structures under investigation can be directly examined using prepared specimens and laboratory equipment. However, the implementation of practical work in schools does not always align with the intended learning objectives. Factors such as the availability of laboratory facilities, time constraints, student readiness, and understanding of experimental procedures may influence the implementation of practical activities (Fitri & Wahyu, 2023). Biology practical work in senior high schools continues to face challenges related to laboratory utilization and the effective implementation of practical activities. Students' laboratory skills also require particular attention, as developing the ability to perform experimental procedures accurately requires direct experience and repeated practice (Sonbuchner et al., 2021).

Practical procedure videos can help students understand the steps involved in laboratory activities before conducting experiments. By presenting procedures through moving images, these videos allow students to observe the sequence of activities, the use of laboratory equipment and materials, and appropriate observation techniques (Mutch-Jones et al., 2021). Instructional videos can also support students' performance in biology laboratory activities. Chen (2022) further demonstrated that laboratory skills can be taught through visual demonstrations of experimental procedures.

The use of instructional videos to teach laboratory skills has been investigated across various disciplines. Heng et al. (2022) found that video-based demonstrations of laboratory procedures can support the development of practical skills. In a systematic review, Noetel et al. (2021) also reported that videos can contribute positively to student learning. Similarly, a systematic review and meta-analysis by Clerkin et al. (2022) indicated that video-based instruction can support the acquisition

of psychomotor skills. In procedural skills education, videos provide students with opportunities to observe specific actions before performing them in practice (Srinivasa et al., 2022).

Research on the use of instructional videos in laboratory practical work has also been conducted in the context of biology education in Indonesia. Interactive laboratory videos have been reported to support senior high school students' laboratory skills (Abu et al., 2022). Nurasmiati et al. (2022) developed laboratory manuals supplemented with instructional videos for senior high school biology education. Similarly, Safitri et al. (2022) developed video tutorials to guide senior high school students in biotechnology practical work. These studies suggest that instructional videos can serve as supplementary learning resources in laboratory activities.

The use of instructional videos does not replace hands-on laboratory practical work. Videos enable students to observe experimental procedures, whereas hands-on activities provide direct experience in operating laboratory equipment, handling materials, conducting observations, and collecting data. Shao et al. (2024) demonstrated that video-based observation and hands-on experimentation make distinct contributions to science learning. Therefore, instructional videos should be integrated as supplementary resources within laboratory practical activities rather than used as substitutes for direct laboratory experience.

The development of practical laboratory skills is also influenced by the design of learning activities. Well-designed and appropriately revised student worksheets can support the development of science process skills (Yusni & Supriatno, 2023). Abas et al. (2024) found that integrating project-based learning can enhance students' science process skills and conceptual understanding. Similarly, Zahirah et al. (2024) reported improvements in science process skills through STEM-integrated project-based learning. In laboratory-based instruction, inquiry-based approaches can also be employed to support the development of students' science process skills (Ana Rato et al., 2024).

Practical laboratory skills should be assessed using methods that align with the competencies being evaluated. These skills are demonstrated through students' performance during laboratory activities, making direct observation an appropriate assessment method (Clevenger et al., 2023). Ulfah and Supahar (2026) also emphasized the importance of valid assessment instruments for measuring science process skills in senior high school biology education.

Previous studies have extensively examined the use of videos and various digital media in laboratory-based learning. Abu et al. (2022) demonstrated that interactive laboratory videos can support laboratory skills among senior high school students. Reeves et al. (2021) investigated undergraduate students' experiences with virtual reality-based laboratory learning, whereas Diwakar et al. (2023) examined students' motivation to engage with virtual laboratories. Darling et al. (2025) reported that laboratory activities incorporating inquiry and collaboration can enrich students' learning experiences. Collectively, these studies suggest that instructional media can

support laboratory learning, although the selection and intended use of such media should be aligned with the characteristics of practical activities. Nevertheless, further research is needed to specifically compare the practical skills of senior high school students who use procedural videos with those who do not, particularly in the context of plant tissue laboratory activities. Such comparisons are important for providing empirical evidence of students' practical skill performance, as assessed through direct observation during laboratory activities.

This study aimed to examine the practical skill performance of students who used biology laboratory procedure videos during plant tissue practical activities and those who participated in laboratory learning without procedural videos. It also investigated differences in practical skills between the two groups of Grade 11 science-track students at Public Senior High School 1 Jeneponto, Indonesia. The findings are expected to provide empirical insights into the potential role of procedural videos as instructional resources supporting biology laboratory activities, particularly in the study of plant tissues.

Methodology

This study employed a quantitative approach using a quasi-experimental method with a *posttest-only nonequivalent control group design.* The study was conducted at Public Senior High School 1 Jeneponto, involving two pre-existing groups without individual random assignment. The experimental group received biology instruction incorporating practical procedure videos on plant tissue, whereas the control group received instruction without the use of such videos. Students' practical skills were assessed once, at the end of the instructional and laboratory activities, through direct observation as a posttest.

The study population comprised 187 eleventh-grade students enrolled in six science-stream classes at Public Senior High School 1 Jeneponto. Cluster random sampling was employed to select two intact classes, eleventh-grade students enrolled in six science-stream classes 3 and eleventh-grade students enrolled in six science-stream classes 4. The sample consisted of 60 students, with 30 students in the experimental group and 30 in the control group. No pretest was administered; therefore, the equivalence of the two groups' practical skills before the intervention could not be established through baseline measurements.

The learning process was conducted in accordance with the teaching module on plant tissue, employing the *Discovery Learning* model through laboratory practical activities. In the experimental group, students watched a procedural video introducing the laboratory equipment and materials and demonstrating the practical procedures before engaging in laboratory activities. Students then prepared the equipment and materials, prepared root, stem, and leaf specimens, and examined them using a microscope. They subsequently recorded, illustrated, and documented their observations,

participated in discussions, and presented their practical findings. In contrast, the control group received explanations of the subject matter and procedural guidance from the teacher before carrying out the same laboratory activities, without the use of a procedural video.

Data were collected through observation and documentation. The research instruments included a practical skills observation checklist and an instructional implementation observation checklist. The practical skills observation instrument comprised five domains encompassing ten assessment indicators. The practical preparation domain assessed students' ability to prepare the required equipment and materials and understand the experimental procedures. The equipment and materials handling domain evaluated the appropriate use of laboratory equipment and adherence to laboratory safety procedures. The practical execution domain assessed students' ability to follow procedures in the correct sequence and complete the activities within the allocated time. The data processing and analysis domain evaluated the accuracy of observation records and students' ability to analyze data and draw conclusions. Finally, the report preparation domain assessed students' ability to organize laboratory reports systematically and provide appropriate annotations for their observations.

Each indicator was assessed using a four-point rating scale (1–4) based on a predefined assessment rubric. A score of 4 indicated the highest level of practical skill performance, characterized by complete preparation of equipment and materials, error-free use of laboratory equipment, systematic execution of experimental procedures, and accurate and comprehensive data analysis and reporting. A score of 3 indicated that most assessment criteria were met, although minor deficiencies remained. A score of 2 indicated that practical skills were not performed optimally, whereas a score of 1 indicated that the assessed skills were not demonstrated in accordance with the established criteria. For the time management indicator, a score of 4 was assigned when the practical work was completed ahead of the allotted time, a score of 3 when it was completed within the allotted time, a score of 2 when completion was slightly delayed, and a score of 1 when the delay exceeded 15 minutes. Scores across all indicators were summed to obtain a total practical skills score ranging from 10 to 40. Direct observations were conducted by an observer using the assessment rubric, while documentation was used to record research activities through photographs, field notes, and supporting documents.

Instrument validity was assessed through content validation involving two experts in biology education. The evaluation focused on the alignment of indicators with the assessed dimensions, clarity of language, and consistency between the instrument and the research objectives. The instrument was considered valid when its indicators adequately reflected the competencies being assessed and the validators recommended it as suitable for use. Instrument reliability was evaluated using Cronbach's alpha in IBM SPSS Statistics version 27, with a coefficient of ≥ 0.70 established as the criterion for acceptable reliability.

Data were analyzed using descriptive and inferential statistics with IBM SPSS Statistics version 27. Descriptive statistics were used to summarize the sample size, minimum and maximum scores, mean, median, and standard deviation of practical skills scores in both groups. The Shapiro–Wilk test was employed to assess the normality of the data distribution, while Levene's test was used to examine the homogeneity of variances between the two groups. The Mann–Whitney U test was applied to assess differences in practical skills scores between the two independent groups because the data did not meet the assumption of normality. Hypothesis testing was conducted at a significance level of 0.05, with the null hypothesis (H_0) rejected when the p-value was ≤ 0.05.

Results and Discussion

The descriptive analysis revealed differences in practical skills scores between the experimental and control groups. The experimental group achieved a minimum score of 38, a maximum score of 40, a mean score of 39.70, and a standard deviation of 0.596. In contrast, the control group obtained a minimum score of 22, a maximum score of 35, a mean score of 28.37, and a standard deviation of 4.382. Given that the data were not normally distributed, the descriptive analysis also included the median and interquartile range (IQR) to characterize the central tendency and variability of scores in both groups. The results are presented in Table 1.

Table 1
Descriptive Statistics of Students' Laboratory Practical Skills Scores

Group	N	Minimum	Maximum	Mean	SD	Median	IQR (Q1–Q3)
Experimental	30	38	40	39.70	0.596	40	0 (40–40)
Control	30	22	35	28.37	4.382	28	8 (25–33)

Based on Table 1, the experimental group exhibited higher mean and median laboratory practical skills scores than the control group. The experimental group had a median score of 40 and an interquartile range (IQR) of 0, indicating that most scores were concentrated at the maximum possible value. In contrast, the control group had a median score of 28 and an IQR of 8, reflecting greater variability in students' scores. This difference was also evident in the standard deviation, which was substantially lower in the experimental group (SD = 0.596) than in the control group (SD = 4.382).

The distribution of scores in the experimental group showed that 23 of the 30 students (76.7%) achieved the maximum score of 40, while five students obtained a score of 39 and two obtained a score of 38. This pattern suggests a potential ceiling effect, characterized by the clustering of scores at the upper limit of the assessment instrument. A re-examination of the assessment data confirmed that the students' total scores corresponded to the sum of scores across the ten practical skills indicators. Nevertheless, the pronounced concentration of scores near the upper limit suggests that the instrument may have limited discriminatory capacity among students

demonstrating high levels of practical proficiency. Therefore, the experimental group's performance should be interpreted cautiously, considering the potential ceiling effect.

These findings are consistent with those of Mutch-Jones et al. (2021), who demonstrated that instructional videos can support students' performance in biology laboratory activities. Chen (2022) also highlighted the potential of video-based demonstrations for teaching laboratory skills. Presenting procedures visually allows students to observe the actions required before performing them in a practical laboratory setting.

The findings of Heng et al. (2022) also indicated that the mode of procedural instruction was associated with students' practical skills performance. A study by Abu et al. (2022) involving senior high school students demonstrated that interactive laboratory videos could support the development of laboratory skills. Similar findings were reported by Nurasmiati et al. (2022) and Safitri et al. (2022), who incorporated videos into guides for biology practical activities. Collectively, these findings further support the use of videos as instructional resources that help students understand laboratory procedures before engaging in practical activities.

Assumption tests were conducted before examining differences between the two groups. The Shapiro–Wilk test yielded significance values of $p < 0.001$ for the experimental group and $p = 0.008$ for the control group. Both values were below the significance threshold of 0.05, indicating that the data in both groups deviated significantly from a normal distribution. Levene's test produced a statistic of 120.359 ($p < 0.001$), indicating that the assumption of homogeneity of variance was not met. These findings provided the basis for employing the nonparametric Mann–Whitney U test to examine differences in practical skills scores between the two groups.

Table 2
Mann–Whitney U Test Results for Students' Laboratory Practical Skills Scores

Statistic	Value
Mann–Whitney U	0.000
Wilcoxon W	465.000
Z	−6.857
Asymp. Sig. (2-tailed)	<0.001

The Mann–Whitney U test yielded a U statistic of 0.000, a Z value of −6.857, and a p-value of < 0.001. As the p-value was below the significance threshold of 0.05, the results indicated a statistically significant difference in laboratory practical skills scores between the experimental and control groups. The experimental group had a mean rank of 45.50, compared with 15.50 for the control group, indicating that students in the experimental group achieved higher practical skills scores. This difference was further supported by the non-overlapping score ranges of the two groups, with scores ranging from 38 to 40 in the experimental group and from 22 to 35 in the control group.

The differences in practical skill performance between the two groups may be associated with how procedural information was presented to students before the laboratory activities. Students in the experimental group had the opportunity to observe laboratory procedures through instructional videos demonstrating the use of equipment and materials, the sequence of experimental steps, and examples of expected observations. This approach provided students with procedural information not only through verbal explanations but also through visual demonstrations of the actions they were expected to perform. Such visual guidance may have helped students develop a clearer understanding of the procedures before engaging in hands-on laboratory activities.

Noetel et al. (2021) demonstrated that instructional videos can contribute to student learning when appropriately integrated into instructional design. Srinivasa et al. (2022) also highlighted the use of videos in teaching procedural skills. Evidence from a systematic review and meta-analysis further suggests that video-based instruction can support the acquisition of psychomotor skills (Clerkin et al., 2022). These findings are consistent with the results of the present study, particularly regarding the use of instructional videos to demonstrate laboratory procedures before students engage in hands-on practical work.

Videos have inherent limitations because they cannot provide direct, hands-on experience in handling laboratory equipment and materials. Students still need to engage in practical laboratory activities to gain experience in operating equipment, conducting observations, recording data, and responding to situations that arise during experimental procedures (Shao et al., 2024). While videos allow students to observe experimental procedures, hands-on experiments provide direct experience in conducting scientific activities. Integrating both approaches sequentially may offer a more comprehensive learning experience than using videos as a substitute for laboratory practical work.

In this study, students' laboratory practical skills were assessed across five domains comprising ten assessment indicators: laboratory preparation, use of equipment and materials, execution of practical procedures, data processing and analysis, and laboratory report preparation. The assessment focused not only on students' ability to follow experimental procedures but also on their readiness to conduct practical activities, accuracy in handling laboratory equipment, ability to process observational data, and capacity to communicate laboratory findings. Acarli and Dervişoğlu (2021) demonstrated that inquiry-based biology laboratory activities can support the development of science process skills. Studies by Farida et al. (2022) and Ramadani et al. (2022) also indicated that laboratory practical activities can be used to develop students' science process skills in science education.

The findings of this study should also be interpreted in the context of the instructional design employed. Yusni and Supriatno (2023) demonstrated that the development and refinement of student worksheets can support the development of science process skills. Abas et al. (2024) and

Zahirah et al. (2024) reported that project-based learning can foster science process skills by actively engaging students in learning activities. Ana Rato et al. (2024) also investigated the use of inquiry-based virtual laboratories to develop science process skills. Collectively, these studies highlight the importance of designing learning activities that provide students with opportunities to apply scientific skills. In the present study, procedural videos were used as supplementary instructional resources to support laboratory practical work rather than as substitutes for hands-on laboratory activities.

Practical skills in this study were assessed through direct observation of students' performance using predefined indicators and assessment rubrics. This observational approach enables the evaluation of skills demonstrated during laboratory activities against established criteria. Clevenger et al. (2023) employed an observation protocol to assess university students' scientific argumentation skills in biology laboratory settings. Ulfah & Supahar (2026) also emphasized the importance of valid assessment instruments for measuring science process skills in senior high school biology education. Together, these studies underscore the need for clearly defined indicators and assessment instruments aligned with the specific scientific skills being evaluated.

Although the difference in scores between the two groups was statistically significant, the findings should be interpreted in light of the study design. This study employed a posttest-only nonequivalent control group design without a baseline assessment (pretest) or individual random assignment. Consequently, the baseline equivalence of the two groups could not be established, and the possibility that other factors contributed to the observed differences in performance cannot be entirely ruled out. Furthermore, most students in the experimental group achieved the maximum possible score, indicating a potential ceiling effect that should be considered when interpreting the assessment results.

Overall, the findings indicate that students who received instruction supported by procedural videos achieved higher laboratory practical skills scores than those who received instruction without such videos. This difference was statistically significant, suggesting the potential value of procedural videos as supplementary instructional resources for biology laboratory activities on plant tissues. However, these findings do not provide sufficient evidence to establish a definitive causal relationship. Procedural videos are therefore best positioned as complementary learning resources that visually demonstrate laboratory procedures, while hands-on practical activities remain essential for developing direct experience in handling equipment, conducting observations, and processing experimental results.

Conclusion

Students who participated in biology laboratory practical work on plant tissues using procedural videos achieved a mean practical skills score of 39.70, compared with 28.37 for students who received instruction without procedural videos. The Mann–Whitney U test yielded $U = 0.000$, $Z = -6.857$, and $p < 0.001$, indicating a statistically significant difference in practical skills between the two groups. Students in the video-assisted group demonstrated higher practical skills scores, as reflected in both their mean scores and mean ranks. Procedural videos may serve as supplementary instructional resources by providing students with visual demonstrations of experimental procedures before they engage in hands-on laboratory activities.

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