Integrated Science Education Journal
Vol. 6, No. 2, May 2025, pp. 97~104
ISSN: 2716-3725, DOI: 10.37251/isej.v6i2.1530

A Descriptive Study of Plant Physiology Practicum Activities

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Article Info

Article history:

Received Mar 03, 2025
Revised May 17, 2025
Accepted May 20, 2025
OnlineFirst May 30, 2025

Keywords:

Higher Education
Laboratorium Activity
Plants Physiology Practicum

ABSTRACT

Purpose of the study: This study aims to describe the practicum activities carried out in the Plant Physiology practicum activities of the Biology Education Tadris Laboratory, IAIN Batusangkar.

Methodology: This descriptive study combines the accuracy of numerical data and a more profound understanding through observation and interviews. The population in this study were all students who took the plant physiology practicum course in the odd semester of 2019, totaling 96 people and six laboratory assistants. Data collection consisted of quantitative data collection using questionnaires and qualitative data through interviews and observations. Quantitative data analysis was carried out using the average percentage score for each activity. Furthermore, qualitative data analysis from observations and interviews was carried out by bringing up themes and information patterns from practicum activities to support quantitative data.

Main Findings: Data analysis indicates that the practicum activities have been executed efficiently, evidenced by a planning score of 80.56 and an implementation score of 79.42. Additionally, the score for follow-up activity was 93.66. The overall average percentage of practicum activity execution was 84.55, indicating good category.

Novelty/Originality of this study: The activities of the practicum are detailed in this article, including planning, implementation, and follow-up. In order to generate comprehensive data, the analysis employs descriptive methods that are supplemented by observational data. Research data was collected from all parties involved in the practicum activities, including students, practicum assistants, and laboratory assistants. In contrast to other researchers who exclusively employ qualitative data with samples of practicum participants.

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1. INTRODUCTION

Institut Agama Islam Negeri (IAIN) Batusangkar is an Islamic college that has a tarbiyah department; one of its study programs is biology education, which develops biological education science through research activities and community service by empowering all learning resources and information technology in the learning process. Biology is one of the learning activities that is closely related to the psychomotor domain or skills [1]. Learning is an activity that is planned and structured in such a way as to assist in the learning process of students. The learning process needs to be equipped with supporting facilities and infrastructure so that the learning process can run well and efficiently.

Facilities are essential for the execution of learning activities. Facilities serve to facilitate the educational process, exemplified by the presence of laboratories in schools and universities [2]. Science education possesses distinct characteristics, as it incorporates systematic approaches to problem-solving and enhances scientific skills through laboratory practicums [3], [4]. Practicum activities represent a significant educational method conducted within laboratory settings [5]. They offer students the chance to apply theoretical knowledge acquired in class to practical situations through experiments [6]. In education, practical activities serve to enhance the comprehension of theoretical concepts and to cultivate the practical skills necessary for future professional endeavors. Plant Physiology is one of the subjects studied.

Plant Physiology is a course that examines the functions of plant structures and their responses to environmental factors essential for plant survival. Movement in plants is influenced by various factors; therefore, practical activities should be incorporated into lectures to facilitate experimentation [7]. Practicum activities in education facilitate the attainment of learning objectives and enhance students' comprehension of the material. Practicum activities in plant physiology are essential for stimulating curiosity, fostering scientific attitudes, enhancing students' comprehension of concepts, and emphasizing direct experiential learning. To effectively instill a lesson concept, an educator must teach it within a real context by connecting it to the surrounding environment [8].

Practicum activities facilitate comprehension of the scientific process, particularly within the context of Plant Physiology; however, challenges may arise during their implementation. Issues commonly encountered in practicum activities arise from various factors, such as inadequate supporting facilities, incomplete practicum materials, insufficient time allocation for practicum sessions, unpreparedness of laboratory assistants in organizing tools and materials, and regulations governing the use of laboratory equipment. The laboratory serves as a learning environment necessitating specific equipment that must be supplied [9]. The laboratory serves as a venue for experimentation to validate scientific and technological concepts. Thus, the effectiveness of a laboratory is contingent upon the adequacy of its facilities and the thoroughness of its administration. Furthermore, effective planning is also essential [10]-[12]. Effective planning serves as a foundational element for any activity.

Practicum activities have existed for an extended period; however, there has been no analysis conducted to evaluate their effectiveness at IAIN Batusangkar. The analysis of practical activities conducted at the Allauddin Makassar campus indicates that the research focus is on the implementation of plant anatomy and physiology practicums, encompassing the available time, practicum preparation, implementation process, and laboratory facilities and infrastructure. The research employs a descriptive quantitative method, focusing on a population of 70 students [13]. Furthermore, the study that conducted at SMA Negeri Klaten, emphasizing the parameters examined, such as laboratory management and the execution of biology practicals. The research employs a descriptive method utilizing observation and interviews, targeting a population comprising students, teachers, and principals. The authors' research examines three aspects: planning, implementation, and follow-up activities [14].

This study aims to describe the practicum activities conducted in the Plant Physiology of the Biology Education Tadris Laboratory at IAIN Batusangkar. The practicum activities outlined occur at three stages of the practicum: planning, implementation, and follow-up. This seeks to provide an overview of the effectiveness of practical activities. This study's results provide valuable insights for educators and curriculum designers in developing effective and high-quality biology practicum activities in the laboratory, encompassing all stages from preparation to follow-up.

2. RESEARCH METHOD

This descriptive research seeks to elucidate actual conditions through the collection, analysis, and integration of qualitative and quantitative methods within a single study or a series of studies, thereby enhancing the understanding of research problems [15]. This approach combines the accuracy of numerical data and a more profound understanding through observation and interviews.

This study's population consisted of 96 students enrolled in the plant physiology practicum course during the odd semester of 2019, along with six laboratory assistants. The sample was acquired through total sampling, meaning the entire population constitutes the sample for this study. This process aims to provide a detailed account of the research findings. Data collection comprises two components: quantitative data collection and qualitative data. Quantitative data were collected through a questionnaire developed from the research instrument indicators established by Angriani [16] and Huda [17]. Qualitative data was obtained through interviews with lecturers, laboratory assistants, and practicum assistants to enhance understanding. Observations were conducted during the implementation of laboratory practicums to analyze interactions in practicum activities.

Quantitative data analysis was performed utilizing the mean percentage score for each activity. Qualitative data analysis was performed through observations and interviews, identifying themes and information patterns from practicum activities to complement quantitative data.

3. RESULTS AND DISCUSSION

3.1. Practicum Planning Stage

The research results at this stage were obtained through questionnaires and interviews. Table 1 shows the results of the questionnaire on the planning of Plant Physiology practicum activities.

Table 1. Plant Physiology practicum planning by lecturer

Planning aspects	Average (%)	Scoring criteria
Discuss with laboratory assistants	75	Sufficient
Practicum assistants	83,33	Good
Practicum materials	87,5	Good
Average	80,56	Good

Table 1 shows that the activities carried out obtained a good value (80.56). However, there are still aspects that have adequate value, namely, discussing with laboratory assistants (75), which shows that laboratory assistants need better communication. Effective communication is facilitated when laboratory assistants possess a certification; however, the absence of such certification may hinder communication related to planning. Laboratory management is suboptimal in the absence of a government training certificate for the manager (laboratory assistant) [18]. This communication addresses the availability of tools and materials, the execution of practicums, and discussions related to the practicum schedule, which is progressing effectively.

The biology learning laboratory plays a critical role; therefore, management aspects and supporting facilities must align with relevant standards [19]. Science laboratory facilities comprise (1) laboratory buildings/rooms, (2) furniture, (3) educational equipment, (4) experimental tools and materials, (5) educational media, (6) consumables, and (7) additional equipment [20], [21]. These facilities facilitate the execution of laboratory practicums. Effective laboratory management requires the establishment of standard operating procedures that serve as guidelines. These include maintaining student attendance lists, laboratory activity diaries, schedules, and records of laboratory equipment users, as well as inventory lists of tools and materials, maintenance schedules and plans, and documentation of financial sanctions for damage or removal of existing facilities [22], [23].

In practicum activities, it is essential for lecturers to have practicum assistants in addition to laboratory facilities. Lecturers establish the quantity of practicum assistants and select candidates according to specified criteria. A practicum assistant is an individual designated by the lecturer to assist students in executing practicum activities [24]. The designated practicum assistant receives guidance regarding his responsibilities throughout the practicum. The lecturer provides the practicum guide to the assistant for distribution to the practicans. The distributed practicum materials are created and revised by the lecturer in accordance with the current situation and the condition of the tools and materials. Practicum assistants assigned by the lecturer are required to perform assistance activities. The assistance activities in the Plant Physiology practicum were successful. The conducted assistance activities aim to communicate the practicum contract and disseminate the practicum guide. An effective preparation stage encompasses the organization of materials, tools, and task division relevant to the practicum topic, along with the development of experimental guides in the form of student activity sheets serving as instructions for the experiment [25].

The planning is reinforced by the findings from interviews with the Plant Physiology Lecturer and the practicum Assistant. The interview results indicated coordination between the lecturer and the laboratory assistant regarding the practicum schedule and the availability of tools and materials. The lecturer evaluated the number of assistants, identified the chosen assistants based on the assessment, and provided instructions to those selected. The chosen assistants received preliminary instructions, including the implementation of quizzes at the start of each practicum activity, clarification of the practicum mechanism and assessment system, and execution of a final evaluation regarding both the format and content of the questions. Practicum activities occur subsequent to the delivery of material in class. The lecturer responsible for the course must prepare teaching materials, including relevant guidelines or guides, to support the implementation of practicums [26]. The practicum materials that were given have been revised to consider the implementation of practicums in the IAIN Batusangkar Laboratory. The lecturer revised the practicum materials by evaluating the condition of the tools and materials in the laboratory.

The practicum assistant received guidance from the laboratory assistant concerning the operation of the equipment. The assistant distributed the practicum guide created by the lecturer during the practicum assistance activity. Support was provided to communicate the tasks to be completed during the practicum activity,

including the distribution of the practicum activity contract and the execution of the lecturer's instructions relayed by the assistant. The practicum indicated that assistance was provided prior to the practicum activity. The interview results indicated that assistance activities for the practicum were conducted prior to the implementation of the practicum by the assistant. The interview results indicated that challenges were encountered in coordinating with fellow practicum peers during the practicum activities. The assistance activities involved providing information to practicum participants about required items as outlined in the practicum guide. Practicum groups that fail to provide the necessary tools and materials will face sanctions from the assistant. Participants in the practicum are required to procure tools and materials promptly, or they will be prohibited from engaging in practicum activities. The planning stages of practicum activities have been successful.

3.2. Practicum Implementation Stage

The research findings data at this stage are divided into three aspects, namely preliminary activities, core activities and final activities of the practicum. In the preliminary stage, the practicum participants take a quiz. The quiz is carried out every time they are going to carry out a practicum activity. The quiz is carried out to see the practicum participants' understanding before conducting practicum observations. The quiz is carried out at the beginning as a measuring tool to determine the extent of the student's readiness and understanding of the material to be observed during the practicum [27]. The subsequent activity requires practicum participants to organize the tools and materials they will bring. The assistant subsequently verifies the adequacy of tools and materials for each practicum group. The assistant subsequently offers a succinct overview of the activities to be practiced.

The core activities carried out in the Plant Physiology practicum are establishing cooperation between practicum participants in their groups and good coordination with the practicum assistant. The activities at the final stage are discussions regarding the results of observations obtained and concluding the results of practicum observations. Activities in implementing the practicum can be seen in Table 2.

Table 2. Plant Physiology practicum implementation activities

Implementation stages	Average (%)	Scoring criteria
Preliminary	83,89	Good
Core	77,62	Good
Final	76,74	Good
Average	79,42	Good

Table 2 explains that the activities involved in implementing the practicum went well. Several prominent aspects and less prominent aspects were present in each of the observed practicum activities. The activities carried out during the practicum implementation process. Table 2 shows that the preliminary activities of the plant physiology practicum received good criteria with an average value of 83.89. The highest observation score with excellent criteria was achieved by the aspect of the practicum wearing a lab coat before entering the laboratory. The same thing is also known from the results of the assistant response questionnaire, which stated that every time the practicum, the assistant continued to monitor the completeness of the practicum attributes, such as lab coats, with excellent criteria. The results of the practicum response questionnaire also showed that the practicum always wore a lab coat before entering the laboratory room, with excellent criteria. The lowest score was obtained by the assistant aspect, which explained the practicum procedures to be carried out with sufficient criteria. In carrying out practicum activities, practicums need to be given clear instructions. In general, the preliminary stage of practicum activities went well [28].

The data presented in Table 2 shows that the implementation of the core activities of the Plant Physiology practicum has good criteria, with an average score of 77.62. At this stage, the highest score with good criteria was achieved by the aspect of the practicum assistant guiding students in work procedures with good criteria. From the results of the assistant response questionnaire, it is known that in the core activities, the practicum assistant always guides students in carrying out procedures with good criteria. This will create a good environment for the practicum. The learning environment will determine the level of student concentration during the learning process [29]. The practicum can be carried out effectively if the necessary tools are available and suitable for use. There are adequate laboratory facilities and infrastructure for students [30]. The results of the student response questionnaire prove that they know the work procedures with good criteria. The lowest score was obtained by the students describing the observed objects with sufficient criteria. Based on observations in the field and also interviews with assistants, the obstacle was ineffective time management in observations. However, in general, the implementation stage of the practicum activities also went quite well.

The data presented in Table 2 shows that the closing activity of the Plant Physiology practicum received good criteria with an average score of 76.74. The highest score with good criteria was achieved by the students tidying up the laboratory equipment used. This aspect also received a score with good criteria from the results of the assistant response questionnaire. In addition, the results of the student response questionnaire also showed

good criteria for this aspect. Tidying up the tools, cleaning them, and putting them back means maintaining the existing facilities so that they can be used again for learning activities [31], [32].

The lowest score was obtained for students conveying observation results with moderate criteria. Based on the results of interviews with assistants and observation results, many students lacked confidence when conveying their observation results. Delivering observation results is an essential skill that students must have in practicum activities; one of the basic skills that must be possessed is communication skills. Communication skills in practicums are carried out when conveying the results of observations and experiments properly in the form of reports or presentations [33]. The final stage of the practicum activity went quite well, but only feedback was not given to review student abilities. After the implementation activities are completed, the results of the practitioner's research must be collected, discussed, and evaluated using tests or simple questions and answers.

3.3 Practicum Follow-up Stage

At this stage, lecturers and assistants supervise and guide the ongoing practicum activities. This activity is known from the results of the lecturer and assistant practicum questionnaire regarding the follow-up activities of the Plant Physiology practicum. The follow-up carried out by the lecturer is in the form of supervision and evaluation in the implementation of the practicum once a week to the practicum assistant. The lecturer plays a role in monitoring practicum activities and conducting routine evaluations to improve the quality of practicum activities [34]. The results of the practicum follow-up activities are shown in Table 3.

Table 3. Follow-up activities of the assistants' Plant Physiology practicum

Follow up aspects	Avearage (%)	Scoring criteria
Instructions and discussions with lecturer	94,65	Very good
Practicum evaluation	92,67	Very good
Average	93,66	Very good

Table 3 shows that in the Plant Physiology practicum activities, the assistants followed up on the practicum activities and their implementation was very good. These results were obtained from interviews with plant physiology lecturers and practicum assistants. Evaluation is a process to obtain data and information needed to determine the extent and how learning has taken place in order to make assessments (judgments) and improvements needed to maximize the results [35].

The results of interviews with lecturers showed that follow-up had been carried out on the practicum activities, where Plant Physiology lecturers supervised the progress of the Plant Physiology practicum, such as asking the practicum assistants how the practicum activities were going, asking about the obstacles they found, and asking about the obstacles faced by practicum participants in making observations. From the interviews, it was found that the obstacles encountered were the small laboratory space and the limited tools and materials available during the practicum, which became obstacles in guiding practicum participants in practicum activities. These obstacles can have a negative impact on the effectiveness of learning activities and the quality of observation results during practicum [36].

The results of interviews with plant physiology practicum assistants explained that practicum assistants often discussed with each other about obstacles during practicum activities. This is done to minimize existing problems. The practicum assistant also evaluates the practicum activities. This evaluation is in the form of a general practicum quiz and a final practicum exam. The general quiz questions and the final practicum exam are made by the practicum assistant with the approval of the lecturer. Therefore, the follow-up activities carried out by the practicum assistant are also known through filling out a questionnaire by the practicum assistant, indicating that the implementation is very good.

The researcher also interviewed students about their opinions about the practicum activities that had been carried out. The results of interviews with students stated that the practicum was less effective because the tools were inadequate and not all practicum assistants provided good guidance in observing the practicum. Incomplete tools and inadequate guidance from the practicum assistant became obstacles for practicum participants to make observations.

The plant physiology practicum activities at IAIN Batusangkar that had been carried out obtained good results from the implementation to the follow-up stage. The overall percentage results can be seen in Table 4.

Table 4. Average percentage of results of Plant Physiology practical activities at IAIN Batusangkar

Stages	Percentase
Planning	80,56
Implementation	79,42
Follow-up	93,66
Average	84,55

Table 4 demonstrates that the plant physiology practicum activities at IAIN Batusangkar are classified as good across the three evaluated aspects. This finding aligns with Agustina's research, which indicated that the availability of practicum tools influences the execution of effective practicums [37]. In contrast to the findings of Rahmah, which identified the management of laboratory assistants as the primary obstacle in the execution of practicums [38]. This study evaluates the aspects of planning, implementation, and follow-up, and offers recommendations for future practicum activities. Ali, conducted an analysis of practicum activities at the Allauddin Makassar campus, focusing on the implementation of plant anatomy and physiology practicums [13]. This analysis included aspects such as time allocation, practicum preparation, the implementation process, and the adequacy of laboratory facilities and infrastructure. The results of the conducted research remain unsatisfactory based on the evaluated aspects. Additionally, research at SMA Negeri Klaten encompasses laboratory management and the execution of biology practicums. Agustina, found that laboratory management was effectively executed and the practicum implementation was highly satisfactory [14].

The results indicate several solutions to enhance the quality of the practicum: (1) Increasing the availability of practicum tools and materials, (2) Expanding the number of assistants, and (3) Conducting periodic surveys to gather student feedback on practicum activities, thereby contributing to more effective practicum implementation. This recommendation proposes a solution for the implementation of Plant Physiology practicum activities, aimed at enhancing the effectiveness of these activities in improving students' observational skills.

4. CONCLUSION

The results and discussion indicate that the practicum activities were conducted effectively, achieving an average percentage of 84.55. The average percentages are as follows: planning at 80.56 (good), implementation at 79.42 (good), and follow-up at 93.66 (very good). The findings of this study suggest that educators and curriculum designers should prioritize communication among all stakeholders, including atudents, assistants, and laboratory assistants, to facilitate the development of effective practicum activities that yield high-quality learning outcomes.

ACKNOWLEDGEMENTS

The author expresses gratitude to the Tarbiyah Department of Biology Education Study Program at IAIN Batusangkar for facilitating data collection. Appreciation is also extended to the lecturers, laboratory assistants, practicum assistants, and students for their collaborative efforts in ensuring the success of this research.

REFERENCES

[1] H. Hasmiati, J. Jamilah, and M. K. Mustami, "Aktivitas dan hasil belajar siswa pada pembelajaran pertumbuhan dan perkembangan dengan metode praktikum [Student activities and learning outcomes in learning about growth and development using the practical method]," *J. Biotek*, vol. 5, no. 1, pp. 21–35, 2017, doi: 10.24252/jb.v5i1.3444.

[2] E. G. Silalahi, M. V. Silalahi, K. Pematangsiantar, and S. Utara, "Analisis standarisasi laboratorium biologi pada sma swasta rk bintang timur pematangsiantar [Analysis of biology laboratory standardization at private high school RK Bintang Timur Pematangsiantar]," *Jurnal Ekonomi, Bisnis dan Teknologi*, vol. 4, no. 2, pp. 6–10, Jul. 2024.

[3] R. Candra and D. Hidayati, "Penerapan praktikum dalam meningkatkan keterampilan proses dan kerja peserta didik di laboratorium IPA [Implementation of practical work in improving students' process and work skills in the science laboratory]," *Edugama J. Kependidikan dan Sos. Keagamaan*, vol. 6, no. 1, pp. 26–37, 2020, doi: 10.32923/edugama.v6i1.1289.

[4] U. M. Nisa, "Metode praktikum untuk meningkatkan pemahaman dan hasil belajar siswa kelas v mi yppi 1945 babat pada materi zat tunggal dan campuran [Practical methods to improve the understanding and learning outcomes of class V MI YPPI 1945 Babat students on the material of single substances and mixtures]," *Proceeding Biol. Educ. Conf. Biol. Sci. Enviromental, Learn*, vol. 14, no. 1, pp. 62–68, Oct. 2017.

[5] P. Prastyawan, "Manajemen sarana dan prasarana pendidikan [Management of educational facilities and infrastructure]," *Jurnal Studi Keislaman*, vol. 6, no. 1, pp. 33–46, 2016.

[6] I. Maulana Fikri and I. Yuniar Wardhani, "Hubungan pengelolaan laboratorium biologi dengan keterampilan praktikum siswa kelas xi mipa SMA Nu Al Ma'ruf Kudus [The relationship between biology laboratory management and practical skills of class XI students of science at SMA Nu Al Ma'ruf Kudus]," *EDU-BIO J. Pendidik. Biol*, vol. 7, no. 1, pp. 21–28, 2024, doi: 10.30631/edu-bio.v7i1.42.

[7] W. Hayati, Irdawati and A. Razak, "Analisis pelaksanaan praktikum IPA biologi kelas VIII semester I selama masa pandemi di SMP negeri Se-Kecamatan Sumpur Kudus [Analysis of the implementation of biology science practicums for class VIII semester I during the pandemic in public junior high schools throughout Sumpur Kudus District]," *Syntax Literate Jurnal Ilmiah Indonesia*, vol. 9, no. 8, pp. 4333–4346, 2024, doi: 10.36418/syntax-literate.v9i8.

[8] A. Adhani and D. Rupa, "Analisis pemahaman konsep mahasiswa pendidikan biologi pada matakuliah fisiologi tumbuhan [Analysis of students' understanding of biology education concepts in plant physiology courses]," *J. Inov. Pendidik. Sains*, vol. 11, no. 1, pp. 18–26, 2020, doi: 10.20527/quantum.v11i1.8035.

[9] R. Mukra, M. Silitonga, and M. Restuati, "Analysis on facilities and intensity of utilization of biology laboratories in four state schools in Medan," *IOP Conf. Series., The 6th Annual International Seminar on Trends in Science and Science Education*, vol. 1462, no. 1, 2020, doi: 10.1088/1742-6596/1462/1/012010

[10] Z. Nurlia and E. Agustina, "Pemanfaatan dan pengelolaan laboratorium bagi guru ipa di madrasah tsanawiyah negeri dan swasta Aceh Besar [Utilization and management of laboratories for science teachers in state and private junior high schools in Aceh Besar]," *Pros. Semin. Nas. Biot*, 2018, pp. 750–755, 2018.

[11] E. Trisianawati, Ita, and K. Fitria, "Analisis kelengkapan alat dan bahan laboratorium ipa sekolah di Kota Pontianak [Analysis of the completeness of science laboratory equipment and materials in schools in Pontianak City]," *J. Pendidik. Sains dan Apl*, vol. 3, no. 2, pp. 66–72, 2020, doi: 10.31571/jpsa.v3i2.2245.

[12] S. Susilo, and G. Amirullah, "Pengelolaan dan pemanfaatan laboratorium sekolah bagi guru muhammadiyah di Jakarta Timur [Management and utilization of school laboratories for Muhammadiyah teachers in East Jakarta]," *J. Solma*, vol. 07, no. 1, pp. 127–137, 2018, doi: 10.29405/solma.v7i1.2380.

[13] A. Ali, "Analisis pelaksanaan praktikum anatomi fisiologi tumbuhan jurusan pendidikan biologi semester genap tahun akademik 2016/2017 [Analysis of the implementation of plant anatomy and physiology practicums for the biology education department, even semester, 2016/2017 academic year]", *jbiotek*, vol. 5, no. 1, pp. 144-154, 2017, doi: 10.24252/jb.v5i1.3454.

[14] P. Agustina, A. Saputra, E. K. Khotimah, D. Rohmahsari, and N. Sulistyanti, "Evaluasi pelaksanaan praktikum biologi di sma negeri di klaten pada ditinjau dari kualitas laboratorium, pengelolaan, dan pelaksanaan praktikum [Evaluation of the implementation of biology practicums in state high schools in Klaten in terms of laboratory quality, management, and implementation of practicums]," *Bio-Pedagogi*, vol. 8, no. 2, p. 105, 2019, doi: 10.20961/bio-pedagogi.v8i2.36148.

[15] J. W. Creswell, *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research Fourth Edition*. London: Pearson, 2012.

[16] R. Anggryani, "Analisis kegiatan praktikum biologi kelas x dan xi sma n 10 padang pada semester 2 tahun pelajaran 2012/2013 [Analysis of biology practical activities for grade X and XI of SMA N 10 Padang in semester 2 of the 2012/2013 academic year]," *Tesis, Jurusan Pendidikan Biologi, Universitas Negeri Padang*, Padang, 2013.

[17] A. M. Hudha, "Analisis pengelolaan praktikum biologi di laboratorium biologi universitas muhammadiyah malang [Analysis of biology practicum management in the biology laboratory of Muhammadiyah University of Malang]," *Jurnal Penelitian dan Pendidikan*, vol. 1, no. 1, 2011.

[18] N. M. Meita, "Studi kelayakan pengelola laboratorium ipa smpn 4 sumenep berdasarkan permendagri 26/2008 [Feasibility study of the management of the science laboratory at SMPN 4 Sumenep based on the Minister of Home Affairs Regulation 26/2008]," *LENSA (Lentera Sains) J. Pendidik. IPA*, vol. 7, no. 1, pp. 40–47, May 2018, doi: 10.24929/lensa.v7i1.19.

[19] R. Kasman and Ermin, "Analisis pengelolaan laboratorium biologi sman 1 halmahera selatan dan 12 tidore kepulauan, maluku utara [Analysis of biology laboratory management at SMAN 1 South Halmahera and 12 Tidore Islands, North Maluku]" *Jurnal JEBS: Journal of Biology Education and Science*, vol. 4, no 3, pp. 1–23, Nov. 2016.

[20] A. Hayati and S. Sumarsih, "Evaluasi standar sarana dan prasarana laboratorium ipa di sekolah model sma negeri 7 bengkulu selatan [Evaluation of the standard of science laboratory facilities and infrastructure at the model school of state senior high school 7, South Bengkulu]," *Manajer Pendidik. J. Ilm. Manaj. Pendidik. Progr. Pascasarj*, vol. 14, no. 2, pp. 60–67, 2020, doi: 10.33369/mapen.v14i2.12827.

[21] N. K. Lase, "Analisis pengetahuan mahasiswa prodi pendidikan biologi ikip gunungsitoli tentang peralatan laboratorium dan fungsinya [Analysis of knowledge of students of the Biology Education Study Program, Gunungsitoli Teachers' Training College regarding laboratory equipment and its functions]," *J. Pendidik. MINDA*, vol. 2, no. 2, pp. 104–115, 2021.

[22] D. S. Fauzia and R. Mukhaiyar, "Konsep administrasi laboratorium pendidikan teknologi kejuruan di departemen teknik elektro universitas negeri padang [The concept of vocational technology education laboratory administration in the electrical engineering department of Padang State University]," *J. Pendidik. Tek. Elektro*, vol. 3, no. 2, pp. 1–4, 2022, doi: 10.24036/jpte.v3i2.174.

[23] F. Harahap, N. Nurliza, and N. E. A. Nasution, "Pengembangan ensiklopedia perbanyakan tanaman melalui kultur jaringan sebagai sumber belajar tambahan untuk siswa sma [Development of an encyclopedia of plant propagation through tissue culture as an additional learning resource for high school students]," *J. Pelita Pendidik*, vol. 8, no. 1, pp. 52–61, 2020, doi: 10.24114/jpp.v8i1.17301.

[24] H. Hikmah Fatimah, D. Fahrudin, and E. S. Setyowati, "Kajian problematika dan standarisasi asisten laboratorium di perguruan tinggi [Study of the problems and standardization of laboratory assistants in higher education]," *INKUIRI J. Pendidik. IPA*, vol. 10, no. 2, p. 118, 2021, doi: 10.20961/inkuiri.v10i2.57254.

[25] E. S. Kurniawan, U. Pratiwi, and S. D. Fatmaryanti, "Asistensi praktikum fisika dan pendampingan fun science project bagi peserta didik di SMA Negeri 9 Purworejo [Physics experiment assistant and fun science project for student in SMA Negeri 9 Purworejo]," *Surya Abdimas*, vol. 3, no. 1, pp. 12–20, 2019.

[26] H. Harlis and R. S. Budiarti, "Pengembangan bahan ajar praktikum dan instrumen penilaian berbasis keterampilan proses sains pada mata kuliah mikologi program studi pendidikan biologi Universitas Jambi [Development of practical teaching materials and assessment instruments based on science process skills in the mycology course of the biology education study program at Jambi University]," *Biodik*, vol. 3, no. 2, pp. 102–112, 2017, doi: 10.22437/bio.v3i2.5501.

[27] C. Rahayu and E. Eliyarti, "Deskripsi efektivitas kegiatan praktikum dalam perkuliahan kimia dasar mahasiswa Teknik [Description of the effectiveness of practical activities in basic chemistry lectures for engineering students]," *Edu Sains J. Pendidik. Sains Mat.*, vol. 7, no. 2, pp. 51–60, 2019, doi: 10.23971/eds.v7i2.1476.

[28] N. K. Roestiyah, *Strategi Belajar Mengajar [Teaching and Learning Strategies]*. Jakarta: Rhineka Cipta, 2001.

[29] Y. Pemba, D. Darmawang, and N. R. Kusuma, "Peran lingkungan belajar terhadap konsentrasi belajar peserta didik di smk Katolik Muktyaca [The role of the learning environment on students' learning concentration at Muktyaca Catholic Vocational School]," *J. Pendidik. dan Profesi Kegur*, vol. 2, no. 1, p. 12, 2022, doi: 10.59562/progresif.v2i1.29859.
[30] N. Hidayati and L. Fauziyah, "Profil kesiapan laboratorium biologi untuk mendukung kerja praktik siswa di ma al-ikhwan Kecamatan Kulim, Kota Pekanbaru [Biology laboratory readiness profile to support student practical work at Ma Al-Ikhwan, Kulim District, Pekanbaru City]," *J. Inov. Pembelajaran Biol*, vol. 4, no. 2, pp. 69–79, Sep. 2023, doi: 10.26740/jipb.v4n2.p69-79.
[31] M. Muliana, S. Wahyuni, and E. Erwing, "Optimalisasi fungsi laboratorium ipamelalui kegiatan praktikum di smp negeri 4 sinjai timur kabupaten sinjai [Optimization of the function of the science laboratory through practical activities at State Middle School 4, East Sinjai, Sinjai Regency]," *JISIP (Jurnal Ilmu Sos. dan Pendidikan)*, vol. 5, no. 3, pp. 387–393, Jul. 2021, doi: 10.36312/jisip.v5i3.2182.
[32] [32] Munarti, and S. Sutjihati, "Standar sarana prasarana laboratorium ipa sekolah menengah atas di wilayah Bogor [Standards for science laboratory infrastructure for senior high schools in the Bogor area]" *PEDAGONAL Jurnal Ilmiah Pendidikan*, vol. 2, no 1 pp. 56-62. 2018.
[33] K. S. Kartini, "Deskripsi perkembangan keterampilan dasar kerja laboratorium kimia siswa sma negeri 1 Singaraja [Description of the development of basic chemistry laboratory work skills of students at Singaraja 1 State Senior High School]," *Hydrog. J. Kependidikan Kim*, vol. 6, no. 1, p. 21, 2019, doi: 10.33394/hjkk.v6i1.1596.
[34] S. Aisyah, Hapijah, Fitriyani, and H. Yuliani, "Manajemen pengawasan dan evaluasi di laboratorium fisika fakultas tarbiyah dan ilmu keguruan (ftik) IAIN Palangka Raya [Supervision and evaluation management in the physics laboratory of the Faculty of Tarbiyah and Teacher Training (FTIK) IAIN Palangka Raya]," *JPIK J. Pendidik. IPA dan Keilmuan*, vol. 4, no. 1, pp. 20–30, 2024, doi: 10.37471/jpik.v4i1.962.
[35] K. D. Hasanah, I. A. Zuhriyah, and N. N. Nurseha, "Konsep dan prinsip evaluasi pembelajaran di mi miftahul ulum 1 gondang concepts and principles of learning evaluation at mi miftahul ulum 1 Gondang [Concepts and principles of learning evaluation at MI Miftahul Ulum 1 Gondang]," *JICN: Jurnal Intelek dan Cendikiawan Nusantara*, vol. 1, no.2, pp. 3155–3167, 2024.
[36] N. Fatmawati, A. Mappincara, and S. Habibah, "Pemanfaatan dan pemeliharaan sarana dan prasarana pendidikan [Utilization and maintenance of educational facilities and infrastructure]," *J. Ilmu Pendidikan, Keguruan, dan Pembelajaran*, vol. 3, no. 2, pp. 115–121, 2019, doi: 10.26858/pembelajar.v3i2.9799
[37] P. Agustina, A. Saputra, L. M. Qonitat, R. D. Utami, and Yohana, "Kesesuaian laboratorium biologi sebagai penunjang pembelajaran biologi di sma muhammadiyah se-surakarta dengan standar laboratorium biologi [Suitability of biology laboratories as a support for biology learning in Muhammadiyah high schools throughout Surakarta with biology laboratory standards]," *Proceeding Biol. Educ. Conf*, vol. 14, no. 1, pp. 559–564, Oct. 2017.
[38] N. Rahmah, I. Iswadi, A. Asiah, H. Hasanuddin, and D. Syafrianti, "Analisis kendala praktikum biologi di sekolah menengah atas [Analysis of obstacles to biology practicums in high schools]," *Biodik*, vol. 7, no. 2, pp. 169–178, 2021, doi: 10.22437/bio.v7i2.12777.