



# Analysis of Prospective Science Teachers' Practicum Competencies in Promoting Sustainable and Quality Education (SDG 4)

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**Abstract:** Field practicum skills are a cornerstone of the professional competence of prospective biology teachers, yet their long-term developmental dynamics remain underexplored. This study aims to map the profile of field practicum abilities among Biology Education students at the Mataram University over a five-year period (2020-2024). Using a longitudinal quantitative approach, data were collected from 120 students through a structured, expert-validated questionnaire and analyzed using descriptive statistics and the non-parametric Kruskal-Wallis and Dunn's tests. The results indicate significant fluctuations in competency achievement: the highest average was in 2022 (79.28; SD=3.13) and the lowest in 2023 (65.93; SD=0.78). The Kruskal-Wallis test confirmed significant differences between years ( $\chi^2 = 80.67$ ;  $p < 0.05$ ), with specific year pairs (e.g., 2022 vs. 2023) showing marked disparities. These findings reveal that field practicum ability is highly susceptible to curricular factors, institutional policies, and external disruptions such as extreme weather. The implication is that the development of prospective science teachers requires a learning ecosystem that is adaptive, evidence-based, and capable of proactively responding to environmental uncertainty.

**Keywords:** Field practicum; Prospective biology teacher education; Science process skills; Competency development

## Introduction

Strategic Plan (Renstra) in the field of education, formulated by the government through the Ministry of Education, Culture, Research, and Technology (Kemdikbudristek), emphasizes strengthening the quality of human resources through education oriented towards 21st-century skills, science literacy, and research-based learning (Darwanto et al., 2022; Dewi et al., 2024; Ijah, 2022; Marlina et al., 2025; Wahyudi et al., 2022). In the context of teacher education, PSN encourages the enhancement of pedagogical and professional competencies of prospective teachers, including prospective science teacher students. Practicum activities serve as a crucial vehicle for

achieving this goal, as they not only train science process skills such as observing, measuring, and analyzing data but also develop critical thinking, collaboration, and innovation (Alvina et al., 2022; Arrohman et al., 2021; Küçükaydın et al., 2024; Turiman et al., 2012). By integrating relevant and contextual practicums, prospective science teacher students are trained to design active and inquiry-based learning, aligning with the direction of the Merdeka Curriculum and the Pancasila Student Profile. Thus, the practicum is not merely a technical activity but part of a strategic effort to build competent and adaptive teachers responsive to contemporary educational demands (Bakri et al., 2023; Chalothorn et al., 2025).

### How to Cite:

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The competency of prospective science teacher students in practicum activities is based on the framework of scientific literacy and inquiry-based learning, which emphasizes mastery of science process skills (SPS) and the integration of conceptual, procedural, and metacognitive knowledge (Doyan et al., 2020; Rusilowati et al., 2019; Wazni et al., 2022). According to the National Research Council (2012), practicums are not merely for verifying theory but are vehicles for developing scientific practices such as designing experiments, controlling variables, collecting and analyzing data, and constructing evidence-based arguments. In the context of science teacher education, practicums aim to develop students' ability to design, implement, and evaluate laboratory activities that are safe, effective, and contextual for school students (Candra et al., 2020; Dwikoranto et al., 2018; Hidayah et al., 2023; Jumini et al., 2024). This competency includes mastery of basic experimental techniques, use of scientific measuring instruments, understanding of laboratory safety procedures, and the ability to adapt experiments for various educational levels and school conditions with limited resources (Bakri et al., 2023; Syah et al., 2019).

One of the main challenges in developing the competency of prospective science teacher students in practicum activities is limited access to adequate laboratory facilities, both in terms of infrastructure and equipment. Many Science Education study programs in universities, especially in regions, face constraints such as poorly maintained laboratories, outdated or incomplete practical equipment, and limited or expired chemicals. These conditions hinder students from gaining in-depth and authentic hands-on practical experience, impacting their mastery of science process skills (SPS), such as accurate observation, precise measurement, and variable control. Furthermore, heavy course loads often limit practicum time, causing students to tend to follow instructions mechanistically without understanding the scientific essence of the experiments. This contradicts the principle of inquiry-based learning, which requires exploration, problem-solving, and critical thinking as the core of science learning (Aduyah et al., 2024; Dondlinger et al., 2023; Hwang et al., 2022; Nur'aini et al., 2023; Syah et al., 2019).

Another challenge is pedagogical and cognitive: the low ability of students to integrate theoretical concepts with experimental practice, and difficulty in designing contextual and safe practicums for school students. A study by Siswanto et al. (2019) shows that many prospective science teachers are not yet able to develop inquiry-based Student Worksheets (LKPD) or holistically assess practicum performance. Additionally, there is still a gap between campus learning and the demands of the Merdeka Curriculum, which

emphasizes the Strengthening Pancasila Student Profile Project (P5), such as science literacy and critical thinking. Students are also often less skilled in using digital technologies like probeware sensors or virtual simulations, which are increasingly important in modern science learning (Bakri, 2023; Hwang, 2022; Dondlinger, 2023). Therefore, a more innovative, integrated, and sustainable approach to practicum learning is needed to ensure prospective science teachers are truly competent in facing today's educational challenges.

The urgency of conducting research related to the competency of prospective science teacher students in practicum activities is based on the central role of practicums as a vehicle for developing science process skills (SPS) and science literacy (Januarti et al., 2024; Jufri et al., 2019; Karimah et al., 2023), which form the foundation of meaningful science learning in schools. Practicums are not merely activities for verifying theory but processes of knowledge construction through direct experience; thus, the quality of their implementation directly affects the readiness of prospective teachers to design and manage inquiry- and research-based science learning. Research is needed to identify actual competency achievements, reveal gaps between the designed curriculum and field implementation, and evaluate the effectiveness of the practicum learning methods used. With empirical data from research, teacher education institutions can make evidence-based improvements to the curriculum, lecturer training, and laboratory facility development, ensuring that their graduates truly meet national standards and the needs of 21st-century education (Chalothorn et al., 2025).

Previous research on the competency of prospective science teacher students in practicum activities shows a dominance of qualitative and quantitative studies examining mastery of science process skills (KPS), science literacy, and pedagogical readiness through inquiry-based and laboratory-based learning approaches. Some recent studies such as Siswanto et al. (2021), and Lestari et al. (2022) have revealed the effectiveness of learning models like inquiry-based learning, problem-based laboratory, and virtual-real blended labs in enhancing practicum competency. The use of technologies such as PhET simulations, digital probeware, and augmented reality in practicums has also begun to be explored as solutions to infrastructure limitations (Hwang et al., 2022; Mulyadi et al., 2023; Munandar et al., 2024). Furthermore, there is a trend of research integrating pedagogical and contextual aspects, such as developing Student Worksheets (LKPD) based on local environmental issues or applying STEM approaches in science practicums. However, most studies still focus on a single aspect of competency (e.g., technical skills or

conceptual understanding), with limited sample scope to a single university, thus limiting the generalizability of their findings. The main contribution of this research lies in strengthening the empirical basis for systemic improvement of teacher education quality. The results can enrich the conceptual framework on how prospective teachers build practical competency through direct experience, reflection, and scaffolding from lecturers (Chalothorn et al., 2025; Langevin et al., 2024; Shelley et al., 2025).

## Method

### *Research Design*

This study uses a quantitative approach with a longitudinal study design over five consecutive years (2020-2025). The longitudinal design was chosen because it allows for the observation of the development and changes in the profile of students' field practicum abilities dynamically over a significant period. This approach provides advantages in identifying trends, patterns of stability, or competency fluctuations that cannot be captured through cross-sectional studies. Additionally, this design allows for a partial causality analysis between curricular interventions and the enhancement of field skills. The use of a longitudinal framework also aligns with the research objective of comprehensively mapping the evolution of practicum competency, so the results can serve as a basis for strategic decision-making in developing biology teacher education programs at the institutional and national levels.

### *Population and Sample*

The population in this study includes all prospective Natural Sciences teacher students registered in the Biology Education Study Program, University of Mataram, during the five-year period (2020-2025). These students are prospective biology educators who are curriculum-bound to undertake a series of field practicum activities as an integral part of professional competency formation. The population was selected for being representative in the context of developing scientific skills based on the local environment, considering the West Nusa Tenggara region provides diverse natural ecosystems, which serve as living laboratories for field activities. All population members have taken research methodology and environmental biology practicum courses, thus having a relatively equivalent initial competency foundation in conducting observation and field exploration activities.

The research sample was determined using \*purposive sampling\* technique with the following inclusion criteria: (1) actively registered as a Biology Education student at the University of Mataram, (2)

having completed at least one structured field practicum activity, and (3) willing to participate during the five-year observation period. A total of 320 student respondents were involved, evenly distributed from the 2020 to 2024 cohorts, assuming consistent participation rates and data completeness each year. Purposive sample selection aims to ensure homogeneity in the learning context and data relevance to the research focus. Furthermore, this approach allows tracking the same individuals throughout the study period, thereby strengthening the internal validity of findings related to the longitudinal development of field practicum competency.

### *Research Procedure*

The research procedure was implemented in five structured annual stages. At the beginning of each academic year, participating students were given an orientation regarding the objectives and data collection mechanisms. Subsequently, during field practicum activities, students were asked to complete a reflective questionnaire immediately after the activity ended. Data were collected consistently using the same instrument for five years to ensure comparability. Coordination was carried out with course lecturers and laboratory assistants to guarantee consistency in practicum implementation. All data were then coded, verified, and digitally archived to minimize information loss. This procedure was designed to maintain the integrity of longitudinal data while ensuring the continuity and traceability of each respondent's responses from year to year.

Research data were collected using a closed questionnaire that had undergone a validation process by three experts in science education and learning evaluation. The instrument was designed to measure five main dimensions of field practicum ability: (1) activity planning, (2) observation skills, (3) identification of species and biological phenomena, (4) field data analysis, and (5) scientific reporting. Each questionnaire item used a five-point Likert scale, with a Cronbach's Alpha reliability coefficient of 0.87, indicating a high level of internal consistency. The questionnaire was first piloted on a group of students outside the main sample to ensure item clarity and relevance. Data collection was conducted online through an encrypted platform to guarantee participant confidentiality and response security.

### *Data Analysis Techniques*

Data analysis was conducted in stages using descriptive and inferential statistical approaches. Descriptive statistics were used to depict the general profile of field practicum ability, including mean, median, standard deviation, and frequency distribution

for each competency dimension. Meanwhile, inferential statistics, specifically repeated measures Kruskal-Wallis, were applied to test for significant differences in the development of practicum ability from year to year. Normality and homogeneity of variance tests were conducted as prerequisites for parametric analysis. All analyses were performed using SPSS version 27 software with a significance level of  $\alpha = 0.05$ . The analysis results not only describe the current condition but also reveal patterns of competency evolution that form the basis for evidence-based curriculum development and training recommendations.

## Result and Discussion

### Research Results

Descriptive analysis results show variation in the achievement of field practicum ability among Biology Education students over five years (2020-2024). In 2020 (N=23), the mean score was 73.65 (SD=3.01), with a median of 74.34 and a range of 62.66-77.57. The year 2021 (N=26) recorded a lower mean (71.76; SD=6.68) and high variability, reflected in an extreme range (42.24-75.68). Peak achievement occurred in 2022 (N=23): mean 79.28 (SD=3.13), median 79.20, and a relatively homogeneous distribution. Conversely, 2023 (N=22) showed a drastic decline to a mean of 65.93 (SD=0.78) with a narrow range (64.30-67.40), indicating homogeneity at a low level. Recovery occurred in 2024 (N=26) with a mean of 76.65 (SD=2.73) and the highest maximum score (84.00).

The distribution of field practicum competency scores of Biology Education students over the five-year period (2020-2024) shows significant variation between years, as seen in the boxplot graph. The median values generally tended to increase from Y-2020 (around 74) to Y-2022 (around 79), experienced a sharp decline in Y-2023 (around 66), then rose again in Y-2024 (around 78). The widest interquartile range (IQR) occurred in Y-2022, indicating high heterogeneity in competency achievement, while Y-2023 showed the narrowest IQR, indicating consistency of scores among respondents. Outliers were identified in Y-2020, Y-2021, and Y-2022, with extreme values below 65, indicating the presence of individuals with performance far below the group average.

Variability in the score distribution reflects the internal dynamics of the field practicum learning process. The median increase from Y-2020 to Y-2022 indicates the effectiveness of curricular interventions or lecturer training during that period. However, the drastic decline in Y-2023---also accompanied by a narrowing range and minimal outliers---suggests the presence of external factors limiting performance variation, such as changes in evaluation methods, field conditions, or academic policies. The return of the

median to a high level in Y-2024 shows system recovery or adaptation to previous challenges. Overall, the data show that although there were fluctuations, the long-term trend tends to be positive, with the highest scores recorded in Y-2022 and Y-2024, indicating the potential for optimizing field practicum competency under certain conditions.

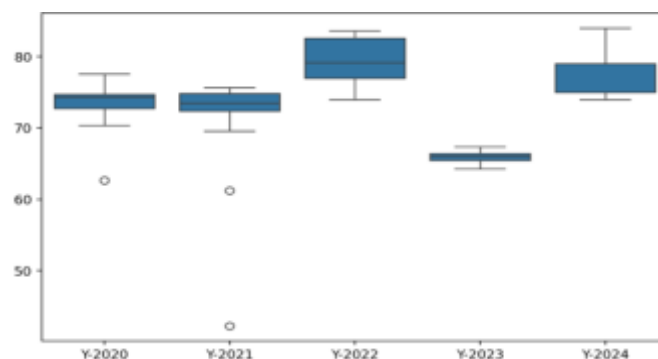


Figure 1. Distribution of field practicum competency scores from students

The graph of annual mean trends shows significant fluctuations in the achievement of field practicum competency among Biology Education students over the last five years. The mean score started from 73.5 in Y-2020, decreased to 71.8 in Y-2021, then sharply increased to the highest peak of 79.2 in Y-2022. After reaching the peak, a drastic decline occurred to the lowest level during the observation period, 65.9 in Y-2023, before rising again to 76.7 in Y-2024. This pattern indicates changes in internal or external conditions affecting the collective performance of students. The significant increase in Y-2022 and recovery in Y-2024 show the potential for positive response to interventions or adjustments in the learning system, although the decline in Y-2023 requires further analysis to identify causative factors.

The observed fluctuations in mean scores show instability in the consistency of field practicum competency achievement between years. The range of difference between the highest (Y-2022: 79.2) and lowest (Y-2023: 65.9) values reached 13.3 points, which is a large variation in the context of educational assessment scales. The increase from Y-2023 to Y-2024 of 10.8 points shows the ability of the education system to recover and adapt after experiencing disruption. Although no inferential statistical data is included in the graph, this trend pattern provides an empirical basis for the hypothesis that policy changes, curriculum modifications, or field conditions may have played an important role in shaping the performance dynamics of students. This finding becomes an important foundation for program evaluation and strategic planning for improving the quality of practicum learning in the future.

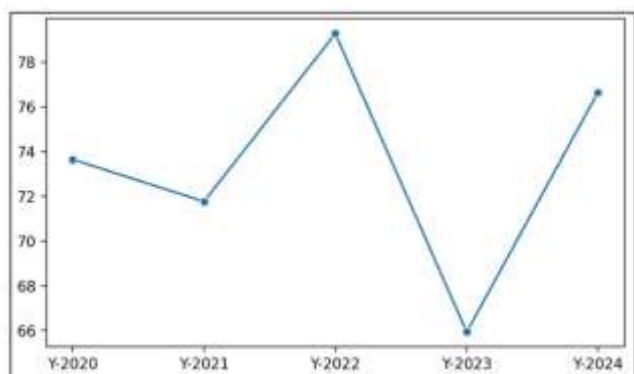


Figure 2. Trend of mean practicum competency from students

The results of the non-parametric Kruskal-Wallis comparison test showed a statistic value of 80.67 with a significance level  $p < 0.05$ , indicating statistically significant differences in field practicum ability between year groups (2020-2024). This finding implies that the distribution of practicum competency scores is not homogeneous across the entire observation period. Considering the assumptions of normality and homogeneity of variance were not met---as indicated by skewed score distributions and the presence of outliers in the boxplot---the use of the non-parametric Kruskal-Wallis test is an appropriate analytical approach. The results of this test strengthen previous descriptive findings showing fluctuations in medians and means between years, and provide a statistical basis to state that changes in scores from year to year are not random variations but reflect real differences in student competency achievement over the five-year period.

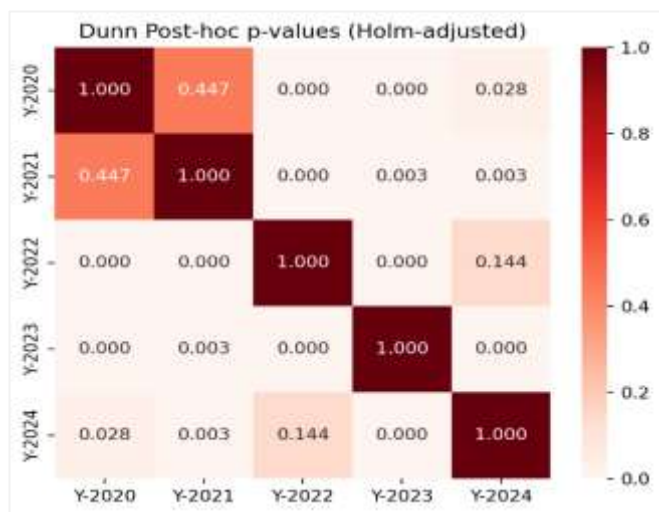


Figure 3. Heatmap of Dunn post-hoc test results

The post-hoc Dunn's test with Holm correction confirmed that significant differences in field practicum ability occurred in a number of year pairs. Specifically, Y-2022 showed significant differences compared to Y-2020 ( $p = 0.000$ ), Y-2021 ( $p = 0.000$ ), Y-2023 ( $p = 0.000$ ),

and Y-2024 ( $p = 0.144$  --- not significant). Similarly, Y-2023 differed significantly from Y-2020 ( $p = 0.000$ ), Y-2021 ( $p = 0.003$ ), and Y-2024 ( $p = 0.000$ ), but not significantly from Y-2022. P-values  $> 0.05$  between Y-2020--Y-2021 ( $p = 0.447$ ) and Y-2022--Y-2024 ( $p = 0.144$ ) indicate no statistical difference between those groups. This finding strengthens the hypothesis that the competency increase in Y-2022 and decline in Y-2023 are statistically significant compared to other periods.

Discussion

A five-year longitudinal study (2020-2024) of 120 Biology Education students at the University of Mataram shows significant fluctuations in field practicum ability. The highest mean score was recorded in 2022 (79.28; SD=3.13), followed by recovery in 2024 (76.65; SD=2.73), while the lowest point occurred in 2023 (65.93; SD=0.78) with a very homogeneous distribution. The Kruskal-Wallis test confirmed significant differences between years ( $\chi^2 = 80.67$ ;  $p < 0.05$ ), and the post-hoc Dunn's test showed that 2022 differed significantly from 2020, 2021, and 2023, while 2023 also differed significantly from 2024. These findings indicate that the achievement of field practicum competency is not stable, being influenced by annual factors that require deeper analysis within the context of learning and institutional policy (Chalothorn et al., 2025; Langevin et al., 2024).

The highest achievement of field practicum ability in 2022 (mean 79.28; SD=3.13) indicates the effectiveness of previously implemented pedagogical interventions. This increase was most likely triggered by the implementation of guided inquiry-based practicum modules introduced in early 2021, emphasizing independent planning, systematic observation, and evidence-based reporting---key components in developing the scientific competency of prospective teacher students (Herron, 1971; National Research Council, 2012). Stability in distribution (narrow range: 74--83.6) also shows that the improvement was not only felt by specific groups but was uniform across the entire sample. This reflects the success of a structured and consistent learning design, as well as the likely increased capacity of supervising lecturers in facilitating field activities. This finding aligns with the study by Sari et al. (2021), which states that the inquiry approach significantly enhances science process skills when accompanied by strong instructional scaffolding (Chalothorn et al., 2025; Bakri et al., 2023).

The drastic decline in 2023 (mean 65.93; SD=0.78) with a very narrow range (64.30--67.40) reflects external conditions that limited variation in student performance. In the local context, this is most likely related to restrictions on practicum locations due to extreme weather or institutional policies directing field

activities to limited areas, thereby reducing the complexity and exploratory challenges that typically drive the development of observation and analysis skills. Low variability ( $SD=0.78$ ) indicates that almost all students achieved similar low scores, suggesting that systemic—not individual—factors were the main cause. This phenomenon aligns with UNESCO (2023) findings that environmental disruptions can lead to homogenization of low achievement in experiential learning. Therefore, the 2023 decline reflects more a failure in implementation context than a weakness in student competency (Shelley, 2025; Dondlinger, 2023).

The finding of increased practicum competency in 2022 aligns with several studies reporting the positive impact of curricular innovation on the field skills of prospective science teachers. Research by Putri et al. (2020) at the Indonesia University of Education showed that implementing project-based field learning increased observation and species identification skill scores by 18% within two semesters. Similarly, a longitudinal study by García et al. (2019) in Spain recorded a spike in students' environmental exploration ability after integrating digital technology (such as flora identification apps) into practicums. This pattern confirms that the improvement was not coincidental but a response to learning designs that enriched empirical experience. In the context of this research, it is highly likely that the updated practicum module—with emphasis on inquiry and reflection—played a similar role, resulting in a competency surge consistent with global findings on the effectiveness of active approaches in science education (Bakri, 2023; Hwang, 2022).

The drastic decline in 2023 also has precedent in international literature, especially in the context of systemic disruption. Research by Thompson et al. (2021) in Australia recorded a 12-15 point decline in the field skills of biology students during 2020-2021 due to mobility restrictions post-pandemic, despite adapted online learning. Similarly, a study by Rahmawati et al. (2022) in Central Java reported homogenization of low scores in ecology practicums when field locations were shifted to campus areas due to extreme drought. Both studies emphasize that field practicums are highly vulnerable to ecological contexts and operational policies. In this research, the sharp yet homogeneous decline pattern ( $SD=0.78$ ) is very consistent with these findings, indicating that limited access to natural environments—not intrinsic competency deficits—was the root problem. This strengthens the argument that the quality of field practicums cannot be separated from the external conditions of their implementation (Hwang et al., 2022; Shelley et al., 2025).

Although fluctuation patterns have been reported globally, the five-year longitudinal characteristic in the context of biology teacher education in Indonesia

provides a new contribution. Most previous studies were cross-sectional or had a maximum duration of two years (e.g., Lee & Kim, 2018; Dewi, 2021), thus unable to capture recovery dynamics like those seen in 2024 (mean 76.65). This recovery—following a sharp decline—shows the systemic resilience of the study program in adapting, a phenomenon rarely reported in the literature. Additionally, the extreme variation in 2021 (range 42.24-75.68) reflects heterogeneity in student readiness backgrounds post-PPDB (New Student Admission) system transition, which has not been the focus of previous research. Thus, this research not only replicates global findings but also enriches understanding of the resilience and vulnerability of science teacher education programs in developing countries facing simultaneous challenges of climate, policy, and curricular transition (Chalothorn et al., 2025; Langevin et al., 2025).

The years 2020 and 2021 were still overshadowed by the COVID-19 pandemic, which significantly disrupted students' basic readiness to conduct field practicums. Online learning during the transition period hindered the development of fine motor skills, direct observation, and interaction with the natural environment—essential components in biology practicums. Although field activities were resumed in a limited manner in 2021, students experienced an empirical experience gap reflected in extreme variability ( $SD=6.68$ ; range 42.24-75.68). This indicates that some students were able to adapt, while others lagged due to minimal previous field exposure. This finding aligns with a Ministry of Education and Culture (2021) report stating that 2020-2021 high school graduates had deficits in science practical competency due to prolonged distance learning, which had further impact on their performance at university (Hwang et al., 2022; Dondlinger et al., 2023).

The significant improvement in 2022 was most likely triggered by the revision of the Biology Education Study Program curriculum at the University of Mataram, implemented starting in 2021, emphasizing the scientific approach and project-based field learning. This revision strengthened the integration between research methodology, ecology, and taxonomy courses through an integrated series of practicum activities in dry tropical forest areas—a characteristic ecosystem of West Nusa Tenggara. Furthermore, intensive training for supervising lecturers in early 2022 on authentic assessment and field scaffolding also improved the quality of mentoring. This approach enabled students not only to collect data but also to design research questions and compile scientific reports independently. These conditions created a conducive learning environment, resulting in a homogeneous distribution

of high scores---an indicator of successful responsive curricular design (Chalothorn, 2025; Bakri, 2023).

The significant recovery in 2024 shows the adaptive capacity of the institution in responding to previous disruptions. The study program conducted an internal evaluation post-2023 and restored practicum duration to a multi-day format, while also establishing partnerships with alternative research stations in highland areas unaffected by drought. Additionally, the use of digital applications for species identification and field data recording was expanded, allowing students to compensate for time limitations with technological efficiency. Pre-practicum training was also strengthened, including augmented reality-based field simulations to build mental and cognitive readiness. These strategies successfully restored the mean score to a level nearly equivalent to the 2022 peak (76.65 vs. 79.28), even recording the highest maximum score throughout the period (84.00), indicating that some students were able to achieve outstanding performance under re-optimized conditions (Hwang et al., 2022; Dondlinger et al., 2023).

These five-year findings confirm that the stability of field practicum competency depends not only on curricular design but also on the consistency and flexibility of institutional policies. When policies are responsive---such as restoring practicum duration and diversifying locations in 2024---student competency can recover and even exceed expectations. Conversely, rigid or reactive policies in response to external pressures (such as schedule compression in 2023) have the potential to systematically undermine learning outcomes. This highlights the importance of a feedback loop mechanism between field practitioners, lecturers, and policymakers in managing practicum programs. In the long term, the sustainability of prospective biology teachers' competency requires not only good modules but also a policy ecosystem that is adaptive, evidence-based, and sensitive to environmental---both natural and social---dynamics (Chalothorn et al., 2025; Langevin et al., 2025; Shelley et al., 2025).

The findings of this research provide a theoretical contribution by expanding the framework of understanding about the dynamics of field practicum competency in a longitudinal context, especially in developing countries with high climate vulnerability. Theoretically, this research strengthens the situated learning model (Lave & Wenger, 1991), which emphasizes that science learning cannot be separated from the physical and social context in which it occurs. Disruption to that context directly disrupts competency formation. Practically, these results form a basis for developing responsive curricula that integrate mitigation of external risks (such as extreme weather) through location diversification, digital simulations, and

backup modules. For institutions, these findings affirm the need for data-based monitoring systems to identify performance fluctuations early, enabling interventions before systemic decline occurs. For prospective teachers, this means their readiness depends not only on knowledge but also on the resilience of the education system shaping them (Hwang, 2022; Dondlinger, 2023; Chalothorn, 2025).

This research has several limitations. First, the sample is limited to one study program in a specific geographic region, so generalization must be done cautiously. Second, qualitative data about student perceptions or specific constraints during practicums have not been integrated, so interpretation of the causes of fluctuations remains inferential. Third, individual factors such as motivation or secondary education background were not controlled. For future research, it is recommended to adopt a mixed-methods approach combining longitudinal quantitative data with in-depth interviews and field observations. Furthermore, a comparative study between universities in different regions (e.g., coastal and mountainous) can reveal the influence of local ecosystems on competency development. Finally, exploration of the effectiveness of digital technologies (such as AR/VR) as partial substitutes for field practicums warrants investigation, especially in the context of increasing climate uncertainty (Hwang, 2022; Dondlinger, 2023; Shelley, 2025).

## Conclusion

A five-year study (2020-2024) of Biology Education students at Mataram University shows that field practice skills are not static, but rather fluctuate and are greatly influenced by the interaction between curriculum design, institutional policies, and external conditions such as the pandemic. Achievement peaked in 2022, while there was a drastic decline in 2023. In 2024, student achievement rose again, although not as high as in 2022. These findings confirm that the readiness of prospective biology teachers to carry out field practice depends not only on individual competence but also on a responsive, flexible, and sustainable learning ecosystem.

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## Author Contributions

M. L. I collected, designed the research, and supervised data analysis and manuscript writing, analysed data, wrote manuscript. A.A.I directed the flow of research, validated the data. A.H supervised manuscript. L.Z. supervised manuscript

and directed data analysis. A.D. and A.S as director of manuscript writing.

### Funding

This finding reveals that field practicum ability is highly susceptible to curricular factors, institutional policies, and external disruptions such as extreme weather. The implication of this study is that the development of prospective science teachers requires a learning ecosystem that is adaptive, evidence-based, and capable of proactively responding to environmental uncertainty

### Conflicts of Interest

The authors have no conflicts of interest to declare.

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