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CONTEXTUAL LEARNING WITH *MEGAPODIUS REINWARDT* ECOTOURISM: A SUSTAINABLE EDUCATION APPROACH AND ITS IMPACT ON STUDENTS' SCIENCE PROCESS SKILLS

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ABSTRACT

This study examines the potential of *Megapodius reinwardt* as an ecotourism attraction and learning resource, as well as the implications of ecotourism-based contextual teaching and learning (CTL) on students' science process skills. The approach employed was a mixed-methods design in both the experimental and control classes. Science process skills data were collected through observation and written pre-tests and post-tests in both groups. Data analysis was conducted both quantitatively and descriptively, as well as qualitatively. Quantitative analysis was conducted on ecological indices, resource use, and the implications of CTL on science process skill. The seven groups of experimental students identified 14-16 characteristics of *M. reinwardt*, including eight unique aspects: nests in the form of mounds of soil mixed with litter, built cooperatively, used collectively, repeatedly, large eggs, buried in the ground, do not incubate their eggs, and do not raise young. Four environmental factors have a big effect on how many *M. reinwardt* there are: how far away they are from the river channel, what kind of trash they are in, how bright the light is, and how dense the vegetation is. The N-gain analysis of post-test scores between the experimental and control classes, employing the Mann-Whitney Test, produced an Asymp Sig value of 0.00 ≤ 0.05, signifying a substantial enhancement in students' science process skills within the experimental class. Ecotourism-based CTL has beneficial and substantial effects on students' scientific process skills while concurrently facilitating the achievement of the Sustainable Development Goals (SDGs) through community empowerment, economic enhancement, environmental preservation, and the advancement of sustainable education.

Keywords: contextual learning; conservation; ecotourism; sustainable

INTRODUCTION

There are big changes happening in many areas of human life today. Therefore, learning is necessary to teach theoretical ideas and help people understand them in a way that links them to real-life situations. However, the delivery is still theoretical and doesn't give any context, which makes it hard for students to understand and appreciate local resources. One way to learn about *M. reinwardt* is to see ecotourism as a real way to learn and a resource. Students develop their comprehension of the world through engagement with the environment, experiences, and social interactions (Mohammed & Kinyó, 2020). The Contextual Teaching and Learning (CTL) method helps students connect what they learn with real-life situations, which helps them understand biological concepts better and in a more meaningful way. This is because they learn in a relevant, interesting, and fun way (Kolb, 2014; Eticha et al., 2024; Okeke et al., 2025). Field exp-

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loration activities can improve students' comprehension of local environmental issues and their significance to the environmental biology curriculum (Yani et al., 2021). Learning experiences that take place in the environment help people learn how to observe, measure, classify, make hypotheses, interpret data, and solve scientific problems (Liu et al., 2024). These abilities, known as science process skills, are the building blocks of scientific knowledge.

Science process skills are important for success because they enhance competitive advantage and productivity, and overcome problems and boredom (Al-Thani & Ahmad, 2025). Science process skills are necessary for achievement in the 21st century (Nabhan & Habók, 2025). Contextual Teaching and Learning (CTL) is a way to learn that gives a variety of these skills. This approach has demonstrated efficacy in enhancing scientific process skills and correlating instructional content with real-world contexts (Kadmayana et al., 2021). Students in the experimental class learned concepts much better than those in the control class, which used an environment-based learning approach (Arisma et al., 2024).

Ecotourism provides genuine educational experiences and serves as an effective medium and resource for learning, fostering environmental awareness and concern while augmenting the understanding of biological concepts (Aswita et al., 2018; King et al., 2024). Jeronen et al. (2016) say that learning outside makes students more motivated and helps them do better in school. Students can learn more and become better readers by observing birds in the wild. For instance, they can learn to tell the difference between 60% more bird species and 46% more about how to collect and analyze data. Lema and Dewi (2023) also said that making an e-module about biodiversity in protected areas greatly improves students' learning and their understanding of why it is important to protect the environment. Mashfufah et al. (2018) underscored the significance of environmental literacy for future biology educators in tackling sustainable ecological issues. Ecotourism is a type of learning that takes place outside. Birdwatching ecotourism is a popular activity for tourists these days (Schwoerer & Dawson, 2022; Pintassilgo et al., 2023; Ocampo-Peñuela et al., 2025).

Birdwatching is a popular activity for many people, including students and future biology teachers, who help protect birds by doing field studies that include ecotourism. Ecotourism is a way to protect the environment and manage resources in a way that will last (Luong, 2025). Ecotourism also helps protect many other species. Using resources through ecotourism is in line with conservation goals to improve the economic and educational benefits of communities (Shah & Ramesh, R., 2022; Bricker & Snyman, 2023). Ecotourism seeks to foster community empowerment, stimulate economic growth, preserve the environment, and improve educational outcomes (Guerrero-Moreno et al., 2024; Wiyono et al., 2023; Kumar et al., 2023). Birdwatching is considered the most scientific of all sports and the most sporty of scientific activities (Janeczko et al., 2021; Randler, 2022; Lundquist et al., 2025). Mangrove ecotourism plays a significant role as an educational and learning tool (Lestari et al., 2020; Verawati & Idrus, 2023). The development of ecotourism as a support for contextual learning can foster environmental awareness among students (Kopnina et al., 2022; Powell et al., 2023; Stern et al., 2025).

M. reinwardt is an interesting bird as an ecotourism object because it has unique characteristics (Yamin et al., 2024; Ahlquist et al., 2020; Harris et al., 2014). Birds are among the animals that exhibit high uniqueness in ecology, science, tourism, and culture (Jayalath et al., 2023). The uniqueness of birds is highly appealing as a subject of study and a tourist attraction (Ivanova et al., 2022; Kunchamboo & Little, 2023). Biodiversity can function as both a medium and a source of biological education (Echeverria et al., 2021; Niemiller et al., 2021). Ecotourism can foster creativity among teachers and students (Sigit et al., 2023; Napitupulu et al., 2025). Studying unique species improves students' understanding of specific adaptations and complex ecological interactions, increases their ecological literacy and conservation awareness, and helps them develop their observational and scientific process skills. Ecotourism that focuses on birdwatching could be a new way to teach biology. This method should help students learn more about biology, get better at doing science, get them more interested in learning, and make them care more about the environment.

This research is imperative as biology educators are pivotal in ensuring that future generations are conscious of and accountable for global environmental challenges such as climate change, pollution, and biodiversity loss. This job fits with the goal of meeting the Sustainable Development Goals (SDGs), especially SDG 4 (Quality Education), SDG 13 (Climate Action), and SDG 15 (Life on Land). These goals show how important education is for teaching people about the environment and how to live in a way that is good for the planet. The ecotourism-based learning approach centered on *M. reinwardt* offers a genuine educational experience through direct engagement with the natural environment. This hands-on experience helps students learn more about how people and the environment are connected in a scientific way (Mohammed & Kinyó, 2020). The integration of CTL improves this process by connecting theory and practice and encouraging critical, argumentative, and creative thinking skills that are important for skills needed in the 21st century. (Kolb, 2014; Novianti, 2022). This kind of learning in the environment also helps with science process skills (SPS), which include observing, measuring, classifying, and solving scientific problems. These skills are the foundation for developing scientific literacy for sustainability and for making meaningful contributions to ecosystem preservation and increasing awareness of ecological issues (Yani et al., 2021; Liu et al., 2024).

The strategic significance of this study within the overarching global sustainability agenda underscores its substantial contribution to the advancement of science education, particularly concerning biodiversity conservation and sustainable development (Oliveira et al., 2025; Hügel & Davies, 2024). The integration of local species into an ecotourism-focused educational model aligns with the UNESCO Education for Sustainable Development (ESD) framework, as it fosters environmental literacy, cultivates sustainability-oriented attitudes, and encourages tangible conservation practices (UNESCO, 2020; Chen et al., 2025). This field-based instructional method corresponds with modern 21st-century science education frameworks that prioritize critical thinking, inquiry-driven learning, collaborative problem-solving, and direct engagement with genuine ecological contexts (Yemini et al., 2025; Fu & Komatsu, 2024). The study contributes to the international discourse on out-of-class learning in biodiverse tropical environments, which are underrepresented in global literature despite their ecological importance. This research illustrates how local ecological assets can be utilized to enhance conservation-focused educational practices and to more effectively amalgamate local ecological knowledge with globally acknowledged sustainability frameworks (Huang et al., 2023). It offers an analytically robust framework for connecting place-based education with the global necessities of environmental stewardship and sustainable development.

Past studies into contextual learning indicate that biological concepts are often imparted through laboratory or artificial simulations. This study seeks to evaluate the efficacy of genuine ecotourism-oriented biology education focused on *M. reinwardt* in delivering authentic, conservation-oriented learning experiences. The research specifically examines its potential to augment students' motivation and engagement, as well as to fortify their proficiency in scientific process skills, biological conceptual understanding, and essential competencies relevant to 21st-century education. This sets it apart from similar studies in the following ways: it is real, it combines conservation and education, it gets students directly involved in educational ecotourism, it uses local resources to boost motivation, and it helps students learn more about science process skills and biological concepts. This method fits with the educational goals of the 21st century, which want students to learn by doing, working together, and actively. Consequently, this research is significant for cultivating science process skills, promoting innovative biology education pertinent to the local context, and enhancing comprehension of biological cognitive concepts.

METHODS

This research employs a mixed-methods framework, specifically the Concurrent Embedded Strategy model, which combines qualitative and quantitative methodologies with varying emphases, implemented either sequentially, non-sequentially, or concurrently (Azhari et al., 2023; Creswell & Guetterman, 2024). The quantitative method evaluates the impact of ecotourism-oriented contextual learning on students' understanding of biological concepts. The qualitative method is utilized to examine students' experiences and understanding of the characteristics of *M. reinwardt*.

The last step in the interpretation process brought together the results of both quantitative and qualitative research to show how ecotourism-based contextual learning changed how students understood biology concepts. This was done by comparing test scores, observations, presentations, and reports. The four steps in this model are: (1) getting ready, (2) putting it into action, (3) evaluating and analyzing, and (4) interpreting. Table 1 shows the different stages of learning.

Table 1. Stages of Ecotourism *M. reinwardt* Based Learning Activities

Stage	Learning Activity	Description	Output
1. Preparation	Identifying topics and objectives	Determining biology topics and learning outcomes based on the characteristics of *M. reinwardt*	Learning objectives and indicators
	Preparing tools	Designing contextual lesson plans, test instruments, and observation sheets	Validated learning tools and instruments
	Location coordination	Collaborating with the Gunung Tunak Nature Reserve management	SIMAKSI & activity schedule
2. Implementation	Pre-test	Giving pre-tests to the experimental and control classes	Students' understanding and initial Science process skills
	Learning intervention	The experimental class undertook an ecotourism project, while the control class used conventional methods.	Students' learning experiences
	Post-test	Giving post-treatment tests to the experimental and control classes	Students' understanding and final Science Process Skills
	Questionnaire completion	Students in the experimental class completed perception questionnaires.	Learning perception data
3. Evaluation and Analysis	Quantitative analysis	N-Gain and *Mann-Whitney* statistical tests were used to compare pre-test and post-test results, using H', E, D, X2, and ANOVA analyses for resource use.	Learning effectiveness test results
	Qualitative analysis	Analysis of observational data on daily activities, reproduction, threats, and predators.	Learning perception and experience themes
	Reports, presentations, and discussions	Integration of quantitative and qualitative data	Comprehensive conclusions on the effectiveness of the method
4. Interpretation	Analysis of statistical test results and qualitative analysis	Interpreting analysis results to understand the effectiveness of the learning approach	Conclusion on the effectiveness of the learning approach
	Data integration and reporting	Combining analysis results and sharing findings with stakeholders	Report, presentation, and discussion outcomes

The participants in this study consisted of 55 students, divided into an experimental class (28 students) and a control class (27 students). The experimental class was divided into seven groups, each consisting of four students. The experimental class employed contextual learning through ecotourism, whereas the control class utilized conventional learning methods, including lectures and discussions. Contextual learning through ecotourism was applied to the discussion of the ecology and reproduction of *M. reinwardt*. The learning activities were conducted twice, each lasting 180 minutes. Both classes were given a pre-test before the learning and a post-test after.

In the first week of the experimental class, the students learned about the biotic and abiotic parts of *M. reinwardt*'s natural habitat by exploring and identifying them. We wrote down the species, number of individuals, canopy height, and stem diameter of all the plants in each sample plot. The Shannon-Wiener Species Diversity Index (H'), Species Abundance Index (E), and Density (D) were used to look at the data, as Sorenssen (Brower et al. 1998) said to do. In the second week, the experimental class looked at the nest and the area around it. Each group used a GPS, a meter, an altimeter, an anemometer, a hygrometer, a pH meter, a thermometer, a lux meter, a camera, an insect net, a questionnaire, a map, and a notebook to gather information. We used the Chi-square test ($\chi 2$) to see how people were using resources over time, and ANOVA to see how living and non-living things affected the presence of *M. reinwardt*.

A quantitative assessment of the nine indicators of students' scientific process skills and their conceptual comprehension of the bioecological traits of *M. reinwardt* was performed via a post-test featuring 25 integrated multiple-choice questions. The test items were subjected to expert validation by three specialists in ecology, science education, and scientific literacy. The validators were granted full autonomy to provide evaluative judgments, annotations, and constructive recommendations to improve the instrument's quality. Based on their collective evaluation, all experts concluded that the instrument was appropriate for use and required only minor revisions.

The scores were analyzed using the N-Gain and Mann-Whitney tests because the data were not normally distributed or homogeneous (Artacho et al., 2021; Knief & Forstmeier, 2021). Furthermore, assessments were taken from reports, presentations, and discussions of field visit results. The results of applying ecotourism-based CTL to students' science process skills and understanding of biology concepts were evaluated by examining the increase in pre-test and post-test scores. The increase in scores was expressed as Normalized Gain (N-gain) using the Hake (1999) equation. N-Gain scores were grouped into three categories as presented in Table 2.

Table 2. Category of N-Gain Score

Score Range	Conversion (%)	Category
$g < 0.3$	$g < 30$	Low
$0,7 < g \geq 0,3$	$70 < g \geq 30$	Moderate
$g \geq 0.7$	$g \geq 70$	High

RESULTS AND DISCUSSION

The science process skills aspects measured in the *M. reinwardt* ecotourism-based CTL include nine indicators, as presented in Table 3. The establishment is the result of an operational simplification of the SPS framework formulated by Padilla and AAAS. Although both frameworks include a broader list of basic and integrated skills, these nine indicators were chosen because they fully represent the core of the scientific process, from data collection to concluding (Ceran & Ateş, 2020; Idris et al., 2022). In addition, these indicators are more relevant and easier to apply in the context of learning and assessment in schools, as they are measurable, non-overlapping, and reflect a systematic scientific thinking flow. This simplification also makes it easier for teachers and educational researchers to develop observation instruments, assessment rubrics, and data analysis without losing the essence of the science process skills they aim to develop (Artayasa et al., 2023). More than 50% of students performed well in science process skills, specifically in observing (71%) and measuring and classifying (54%).

Table 3. Observation of Science Process Skills of Prospective Biology Teachers in 2025

No	Indicator of Science Process Skills	∑ Student. Score		
		1	2	3
1	Observing	5 (18%)	3 (11%)	20 (71%)
2	Measuring	5 (18%)	8 (28%)	15 (54%)
3	Identifying	4 (14%)	11 (39%)	13 (46%)
4	Classifying	4 (14%)	9 (32%)	15 (54%)
5	Tabulating	5 (18%)	14 (50%)	9 (32%)
6	Connecting	12 (43%)	10 (36%)	6 (21%)
7	Predicting	9 (32%)	10 (36%)	9 (32%)
8	Explaining	6 (21%)	10 (36%)	12 (43%)
9	Concluding	13 (46%)	10 (36%)	5 (18%)
	Total Score	63	85	104
	Average	7 (25%)	9.4 (34%)	12 (41%)

Source: Researchers' Data 2025

Six science process skills were performed well by 18% - 46% of students: identifying (46%), explaining (43%), tabulating and predicting (32%), connecting (21%), and concluding (18%). These results are not significantly different from those reported by Agustina et al. (2023), which are as follows: predicting (31%), graphing (28%), interpreting (56%), and concluding (31%). Students' skills in understanding investigative methods leading to scientific knowledge and in organizing, analyzing, and interpreting quantitative data were 59.54% (Khamhaengpol et al., 2021). Overall, the science process skills of prospective biology teachers at the Faculty of Teacher Training and Education, Universitas Mataram, were categorized as follows: 41% in the good category, 34% in the moderate category, and 25% in the low category.

Areif et al. (2018) reported 12 habitat components that influence *M. reinwardt*: altitude, distance from river channels, distance from roads, slope, soil acidity, canopy cover, light intensity, temperature, humidity, soil texture, and the number of predators. Vegetation was overlooked, as its characteristics significantly influence the presence and activity of birds in the Megapodiidae family (Radley et al., 2024). Based on vegetation observations by students, groups I, II, III, IV, V, VI, and VII recorded 13, 12, 8, 9, 10, 9, and 10 species, respectively. Identification and classification of vegetation from the seven student groups yielded 21 vegetation species in the Gunung Tunak Nature Reserve. The vegetation communities within each student group varied in terms of the number and type of vegetation, as presented in Table 4.

Table 4. Number of Species, Species Diversity Index (H'), Evenness Index (E), Density (K), and Dominant Species in the *M. reinwardt* Nest Mound area in the Tunak Mount Nature Reserve in 2025

Group	I	II	III	IV	V	VI	VII
Number of Species	13	12	8	9	10	9	10
H' Index	2.47	2.23	1.98	1.98	2.20	1.98	2.20
E Index	0.96	0.92	0.95	0.90	0.96	0.90	0.96
Density (D)	84	118	240	192	344	396	58
Community	*Tamarindus indica, Chromolaena odorata, Margarithria indica*	*Schoutenia ovata, Protium javanicum*	*Bambusa blumeana*	*Bambusa blumeana*	*Bambusa blumeana*	*Bambusa blumeana*	*Dalbergia latifolia, Chromolaena Odorata*

Source: Research Team Survey 2025

The seven student groups reported 21 vegetation species. Group I reported the highest vegetation species diversity, with 13 species and an H' of 2.47, while the lowest group was Group III, with eight species and an H' of 1.98. The vegetation species diversity index describes the services provided by its community, such as food sources, play areas, rest areas, and animal shelter (Syukur et al., 2023). If the H' value is 1, it means low species diversity, perhaps there are only a few or only one species; if the H' value ≥ 1, it means high species diversity (Krebs et al., 1989). According to van Balen (1999), a value of H' ≤ 2 indicates low species diversity, while a value of H'≥ 2 indicates high species diversity. Based on these two criteria, the vegetation species diversity index in the seven Megapodius nest mound areas in the Gunung Tunak Nature Reserve is classified as moderate. In other words, the vegetation community in the Gunung Tunak Nature Reserve is a relatively stable ecosystem.

Based on the student groups' exploration of environmental components in the nest area and its surroundings, group I recorded 14 aspects, group II 16, group III 15, group IV 14, group V 16, group VI 15, and group VII 15. The number of environmental aspects observed by the seven student groups consisted of 16 components from the seven nesting areas of *M. reinwardt*. The results of the analysis of *M. reinwardt's* tendency to select these components are presented in Table 5.

Table 5. Environmental Component Preference Test of *M. reinwardt* Nesting Area in Tunak Mount Nature Reserve in 2025

Nest	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}
	7	575	45	0	20	200	-	75	-	6.8	440	-	8	67	240	28	1
II	0	790	100	0	20	170	80	75	43	6.7	150	-	9	69	292	28	3
III	7	745	85	15	36	500	-	40	50	7.0	460	32	13	70	84	29	-
IV	10	1025	163	20	15	25	-	50	-	6.8	240	37	10	71	344	29	-
V	5	490	125	0	25	1000	60	40	3	7.0	455	-	12	69	108	30	2
VI	7	1285	200	15	7	100	35	25	-	6.8	1160	70	10	-	78	31	1
VII	12	740	175	0	15	10	50	50	40	6.8	900	-	9	74	396	29	-
∑	38	5650	893	50	138	2005	225	355	136	47.9	3805	139	71	420	1542	204	7
Mean	6.8	807	128	7.14	19.4	286	56	50.7	34	6.8	543.57	35	10	70	816	29	0.85
Chi-X^2	2.29	0.87	0.43	2.00	0.86	0.00	2.29	0.04	0.74	2.00	0.00	2.00	86	0.74	0.00	1.57	1.57[b]
df	4	4	3	2	4	6	4	3	5	2	6	2	4	5	6	2	3

Description:
Y = active hole; X_1: nest diameter (cm); X_2: mound height; X_3: slope; X_4: altitude (asl); X_5: distance from river channel (meters); X_6: canopy cover (%); X_7: litter composition; X_8: distance from road (meters); X_9: soil acidity (PH); X_{10}: light intensity (lux); X_{11}: soil texture; X_{12}: number of vegetation species; X_{13}: humidity (%); X_{14}: vegetation density; X_{15}: temperature (^{0}C); X_{16} = number of predators

The seven student groups' ecological observations of *M. reinwardt* yielded data on diverse ecological aspects. Overall, the students identified 17 relevant ecological aspects. Of these, 12 ecological aspects were consistently observed by all seven groups: number of active nests, nest diameter, mound height, slope, elevation, distance from river channels, canopy cover, litter composition, distance from roads, soil acidity, light intensity, and soil texture. Five additional aspects were noted exclusively by particular groups: vegetation species, vegetation density, temperature, and predator count. There were 14 ecological aspects that two groups found, 15 that three groups found, and 16 that two groups found (Table 5). Students' observations often miss a lot of important details. Four groups didn't pay attention to the texture of the soil. Three groups didn't pay attention to the number of predators, the distance from roads, or the canopy cover. Only one group missed the humidity. The number of ecological aspects noted indicates variations in field experience, observational methodologies, focal points, sensitivity, and the profundity of ecological analysis. This result is consistent with earlier studies highlighting the significance of observational skills in ecotourism education (Huang et al., 2023). Active participation in contextual learning experiences, such as ecotourism, can improve students' critical thinking and ecological observation abilities (Falk & Dierking, 2018; Ardoin et al., 2020). These results highlight the necessity of implementing an ecotourism-oriented methodology in biology education. Students can directly investigate the complexity and ecological dynamics of species like *M. reinwardt* through genuine field experiences. Project-based science learning greatly boosts students' creativity (Artayasa et al., 2024).

The test of the effect of the sixteen variable factors on the presence of *M. reinwardt*, using multiple linear regression analysis with the stepwise method at $\alpha = 0.05$ for each F value at a significance level of $p \leq 0.05$. This means that the sixteen independent variables (X1-X16) collectively have a significant effect on the frequency of occurrence of *M. reinwardt* in each selected area (Table 6).

Table 6. Regression Analysis: The Effect of Abiotic Components on the Presence of *M. reinwardt*

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	86.857	6	14.476	.	.[b]
Residual	.000	0	.		
Total	86.857	6			

Using Chi-X2 analysis to test the tendency of variable factor selection toward nesting areas again, we found that *M. reinwardt* preferred four factors: distance from the river channel, litter composition, light intensity, and vegetation density. Six factors have been identified as influencing *M. reinwardt's* nesting site selection: light intensity, proximity to the river channel, canopy cover, vegetation density, humidity, and plant litter composition (Arief et al., 2018; Yamin et al., 2024).

Based on the literature review, presentations, and student discussions about what makes the *M. reinwardt* bird special, two groups came up with nine unique traits. *The M. reinwardt* bird's nest is a mound of soil and plant litter that is 807 cm wide and 128 cm tall on average. Everyone works together to build the nest. There are 5 to 12 parents who share each nest mound for years. The eggs are pretty big and are buried in the ground. The *M. reinwardt* bird does not sit on eggs or care for its young. Five groups of students found six different things about the bird (points 1–6). This result is in line with earlier studies that showed *M. reinwardt* nests are made of soil mounds and do not hatch their eggs (Ritchison, 2023; Neilly et al., 2021). It looks like the *M. reinwardt* nest at the study site is in pretty good shape. There are no signs of predatory disturbance, especially by people. The average temperature is 29°C, but it can drop to 19°C or rise to 31°C. The average humidity in the air is 68%, but it can be anywhere from 58% to 74%. The light level in the nesting area varies from 150 Lux to 1160 Lux (Table 5).

The research team made ecotourism rules to teach people about *M. reinwardt's* ecology, how it adapts, and how it breeds. The first is conservation, which teaches students why it's important to protect natural habitats and native species like the Megapodius. It also helps with managing and protecting the environment. Ting and Cheng (2017) say that a clear explanation of ecotourism can help students learn more about environmental problems and how they feel about them. The second thing is learning. Spending time in nature can help students learn more about how *M. reinwardt* interacts with its environment and the culture around it. Ecotourism that is based in communities helps people learn more about conservation (Masud et al., 2017). Ecotourism packages need to fit in with people's daily lives and culture in order to be useful (Kurniawan et al., 2022). The third is getting the people in the area involved, which helps keep the economy and resources strong. People in the area who go ecotourism feel more responsible for taking care of the environment (Gumede & Nazama, 2020; Sobhani et al., 2022). Ecotourism also improves the lives of locals in terms of money and social life (Eshun & Tichaawa, 2019; Kunjuraman et al., 2022). It also protects the environment by, for example, properly disposing of trash, using resources wisely, and keeping the number of visitors low. For ecotourism destinations to last over time, people need to be aware of the environment (Chan & Saikim, 2022).

The results of the pre-test analysis of students' science process skills in the experimental and control classes showed an average score of 42 in the experimental class and 41.7 in the control class. Both are classified as lacking (Table 7). One cause of low science process skills is the use of non-contextual learning techniques (Hartono et al., 2023). This existing condition suggests that students' abilities before learning still need improvement. Furthermore, to determine the difference in initial abilities between the two classes, an N-Gain difference test was conducted using the Mann-Whitney test, as the two samples were not normally distributed and the sample sizes differed. The result obtained an Asymp Sig value of 0.948. If the Asymp Sig value is less than or equal to 0.05, it indicates a statistically significant difference in science process skills between students in the experimental and control classes (Senisum et al., 2022; Kassaye et al., 2025). Based on these criteria, students' initial science process skills in the experimental and control classes are not significantly different before the ecotourism-based contextual learning process. In full, the results of the pre-test, post-test, and N-Gain analysis of the experimental class and control class are presented in Table 7.

Table 7. Pre-test, Post-test, and N-Gain Analysis of Science Process Skills of Prospective Biology Teachers in 2025

	Experimental Class					Control Class				
	Pre-test	**Post-test**	**g**	**N-gain (%)**	**Category**	**Pre-test**	**Post-test**	**g**	**N-gain (%)**	**Category**
Mean	42	79.4	37.4	65.54	Moderate	41.7	61.2	21.2	38.21	Low
Min	19	55	17	44.44	-	28	34	5	4.35	-
Max	63	92	54	92.98	-	60	85	50	68	-
ID	29	29	-	-	-	27	27	-	-	-

Mann-Whitney Pre-test Asymp. Sig. 0.948

Mann-Whitney Post-test Asymp. Sig. 0.000

N-Gain % Category: ≥ 75 highly effective; 56-75 effective; 40-55 less effective; <40 ineffective (Hake, 1999).

Source: Research Team 2025

The average N-gain of the control class was 38.21, classified as low, with a distribution across three categories: effective (26%), less effective (30%), and ineffective (44%). The average N-gain of the experimental class was 65.54%, classified as medium, spread across three categories: highly effective (38%), effective (34.5%), and less effective (27.5%). There was none in the ineffective category. The improvement in students' science process skills scores through practical learning was, on average, in the medium category (Supasorn et al., 2022). The scores and analysis of the pre-test and post-test of students' science process skills in the experimental and control classes are presented in full in Table 7.

The average post-test score for the experimental class was 79.4, and for the control class, 61.2. The results of the N-gain difference test for the post-test between the experimental and control classes using the Mann-Whitney Test showed an Asymp Sig value of $0.00 \leq 0.05$. These results indicate a significant difference in science process skills between the experimental and control classes. In other words, there was a significant increase in students' science process skills after the learning. The comparison between pre-test and post-test scores provides a quantitative picture of the impact of the learning implemented. Humorous and relaxed learning outside the classroom improves cognitive and affective learning outcomes (Ngai et al., 2025; Stahlhut et al., 2025). The big jump in post-test scores shows that the students were really engaged in learning and were able to get better at the science process skills. These findings suggest that a context-based biology learning approach that links content to real-world situations via ecotourism can enhance concept retention and foster critical thinking and the application of knowledge among students. This finding aligns with Hardianti and Wusqo (2020), who reported that more than half of the students (69.23%) achieved the scientific literacy standard, and a substantial majority (93.7%) agreed that the experimental model was advantageous and expressed a willingness to apply it in future endeavors. Education that includes hands-on experience with ecotourism activities has a big effect on people's attitudes, motivation, and behaviors that help protect the environment (Liu et al., 2024; Duong & Ngo, 2025). Mangrove ecotourism that is based on education helps students learn more about how ecosystems work and how many different kinds of life there are (Surjanti et al., 2020).

CTL enhances students' Science Process Skills (SPS) by establishing explicit connections between real-world contexts and scientific concepts. This makes it easier for students to ask questions, work together, think about what they learned, and use what they learned in new situations (Picardal & Sanchez, 2022; Melesse et al., 2025). CTL does not treat science as just a collection of facts; instead, it treats it as a methodical way to find out more about things. Through its pedagogical mechanisms, CTL intentionally cultivates core scientific skills, including observation, measurement, analytical reasoning, evaluative judgment, and scientific inference (Demelash et al., 2023). Context-based learning further motivates students to interact directly with genuine phenomena, perform measurements and experiments, recognize and regulate variables, analyze and interpret empirical data, and assess methodologies and experimental results (Ngozi, 2021). As a result, the entire range of Science Process Skills is thoroughly developed and integrated. This study provides three primary contributions. First, it empirically shows that using the natural environment as a real laboratory for ecotourism-based CTL instruction improves students' SPS. Second, it theoretically strengthens and expands the conceptual underpinnings of CTL and inquiry-based learning by positing that ecotourism environments can facilitate significant learning and enhance scientific comprehension. Third, it has real-world effects on teachers and schools by pushing for the use of local environmental resources, the creation of field-based teaching materials, and the building of relationships with managers of conservation areas. The findings collectively enhance initiatives aimed at bolstering ecological literacy and cultivating 21st-century competencies.

CONCLUSION

This study effectively illustrated that *M. reinwardt's* ecotourism-oriented Contextual Teaching and Learning (CTL) yielded positive and significant effects on the Science Process Skills (SPS) of aspiring biology teacher students across all SPS indicators, encompassing observing, measuring, identifying, classifying, tabulating, interpreting, predicting, explaining, and concluding. This method not only improves SPS, but it also promotes ecological awareness, scientific attitudes, and a sense of social responsibility for protecting the environment. This method not only makes education better, but it also protects biodiversity and gives power to local communities. Overall, this model helps reach Sustainable Development Goals (SDGs) 4, 8, and 15 by promoting sustainable education, strengthening ecotourism, and protecting biodiversity.

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