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Ecological-Themed POEW in English for Biology Academic Writing: A Mixed-Methods Pilot Study with Repeated Measures

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Abstract

Academic writing poses persistent challenges for Biology Education students, who must navigate English accuracy, paragraph organization, and scientific reasoning simultaneously. This pilot mixed-methods study with repeated measures examined the implementation of an ecological-themed Predict-Observe-Explain-Write (POEW) model in an English for Biology course and explored students' perceptions of the learning process. Eight second-semester Biology Education students at Universitas Muhammadiyah Parepare, Indonesia, participated in a one-group repeated-measures design. The intervention comprised four 100-minute sessions, each addressing a distinct ecological theme (ecosystems, food chains/food webs, biodiversity, and environmental issues). Students completed academic paragraph-writing tasks at four time points (pretest, midtest, posttest, and two-week follow-up), scored using the ESL Composition Profile, while semi-structured interviews provided qualitative data analyzed thematically. The Friedman test revealed a significant difference across the four measurements, $\chi^2(3) = 18.75$, $p < .001$, Kendall's $W = .78$. Wilcoxon signed-rank tests indicated significant gains from pretest to posttest ($Z = -2.521$, $p = .012$) and from pretest to follow-up ($Z = -2.394$, $p = .017$), though the posttest-to-follow-up decline was not significant ($Z = -1.751$, $p = .080$). Interview data yielded three themes: vocabulary and pronunciation support, improved paragraph organization and idea mapping, and difficulties during the prediction stage due to limited ecological vocabulary. Theoretically, this study contributes to the integration of inquiry-based learning principles with ESP pedagogy by illustrating how a staged cognitive sequence (POEW) may help manage the cognitive demands of L2 academic writing. Practically, it offers a replicable instructional framework for EFL lecturers teaching scientific writing in biology education, with a specific emphasis on vocabulary scaffolding prior to prediction activities.

Keywords: *POEW model; Academic writing; English for Biology; English for Specific Purposes; Ecological themes*

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1. Introduction

Academic writing constitutes a core competency in higher education, demanding that students transform disciplinary knowledge into coherent, evidence-based texts. This competency becomes particularly complex in science education programs, where students must master scientific concepts, employ discipline-specific vocabulary, organize claims and evidence logically, and express these accurately in English. Consequently, Biology Education students enrolled in English for Biology courses require more than decontextualized grammar instruction; they need learning activities that explicitly connect language production with scientific observation, concept formation, and explanatory reasoning.

Recent scholarship emphasizes that academic literacy is discipline-specific and is most effectively developed when language specialists and subject lecturers connect rhetorical, lexical, and epistemic expectations to authentic disciplinary tasks (Wingate, 2018; Hyland, 2022). For multilingual writers, difficulty is not limited to grammar; it also involves confidence, writer identity, and access to the specialized discourse practices valued by academic communities (Flowerdew, 2020; Zotzmann, 2021). Similar problems have been documented among Indonesian EFL students, particularly in organizing arguments, selecting appropriate vocabulary, and maintaining coherence (Toba et al., 2019).

Numerous studies have documented students' academic writing difficulties, which frequently center on lexical choices, coherence, cohesion, paragraph structure, and idea development (Ningrum, 2023). These difficulties are amplified in English for Specific Purposes (ESP) contexts, where writing occurs within a disciplinary framework rather than a general language classroom. For Biology Education students, composing texts on ecosystems, biodiversity, food chains, and environmental issues necessitates familiarity with concepts that are often unfamiliar in English. This situation presents a practical pedagogical challenge: writing instruction must simultaneously foster linguistic accuracy, content understanding, and scientific reasoning.

Vocabulary is especially consequential in discipline-based writing because apparently general academic words may function differently across fields, and students need repeated exposure to the lexical patterns of the target discipline (Durrant, 2016). Genre-oriented scaffolding can also make the organizational expectations of academic texts more visible to EFL learners and support movement from content knowledge to structured written production (Nagao, 2019).

ESP theory underscores the alignment between language instruction and learners' academic or professional needs (Hutchinson & Waters, 1987; Dudley-Evans & St. John, 1998). Contemporary content-based and CLIL-oriented approaches further argue that language learning becomes more meaningful when students use English to process subject matter. Recent CLIL research supports this integration. For instance, Susilawati (2023) found that integrating disciplinary content with online writing tasks enhanced ESP students' writing performance and learning experiences, while Montoya (2023)

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demonstrated that CLIL-based writing instruction improved learners' ability to express content in English. A systematic review by Idris et al. (2025) confirmed that CLIL tends to support writing outcomes when language and subject-matter goals are jointly planned. Systematic evidence likewise indicates that content-and-language integration generally produces positive language outcomes when disciplinary content, language objectives, and instructional support are explicitly coordinated, although effects vary by context and design quality (Goris et al., 2019; Graham et al., 2018). However, these studies generally treat content integration as a broad pedagogical orientation, rather than as a staged inquiry sequence that guides learners from prediction through evidence and explanation to final composition.

The Predict-Observe-Explain-Write (POEW) model offers a relevant instructional sequence for this purpose. The model asks students to predict a phenomenon, observe evidence or information, explain their understanding, and write based on their reasoning. This sequence is rooted in constructivist learning because students actively build meaning through prediction, verification, explanation, and written reflection. Previous POEW research has reported positive effects on writing ability and science learning outcomes. However, most studies have focused either on general English writing or science conceptual understanding. Few studies have examined how POEW can be used in English for Biology to support academic paragraph writing through ecological content.

Research on writing-to-learn in STEM further shows that scientific writing can function as a tool for conceptual learning when students are required to connect claims, evidence, and explanations rather than merely reproduce information (Reynolds et al., 2012; Moon et al., 2018; Gere et al., 2019). Argument-focused inquiry is likewise associated with the development of scientific literacy because it requires learners to justify interpretations and evaluate evidence (Cavagnetto, 2010). These findings provide a broader empirical basis for the Explain and Write phases of POEW.

Ecological themes are suitable for integrating POEW and ESP writing. Topics such as ecosystems, food chains, biodiversity, and environmental issues are familiar enough for students to activate prior knowledge, yet complex enough to require scientific vocabulary and evidence-based explanation. These themes also allow students to observe images, diagrams, short scientific texts, and ecological data before writing. In this context, ecology functions as a bridge between scientific literacy and academic literacy. Students do not write isolated paragraphs; they write after engaging with disciplinary input and inquiry-based thinking.

Although the POEW model has been studied in general English writing (Sianna & Syawal, 2017; Mufidah & Dewi, 2021) and science conceptual understanding (Tekindur & Kingir, 2024), no study to date has specifically examined its application within an English for Biology context using a mixed-methods design with repeated measurements across multiple time points. Furthermore, the integration of ecological themes—which are conceptually rich and visually accessible—as the disciplinary content for POEW-based ESP writing instruction has not been empirically investigated. This gap is significant because Biology Education students require not only general writing skills but

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also the ability to produce discipline-specific academic paragraphs that reflect scientific reasoning processes.

A strong theoretical rationale for the POEW sequence can be drawn from Cognitive Load Theory (Sweller, 1988), which posits that instructional design should manage the intrinsic, extraneous, and germane cognitive loads imposed on learners. By breaking the complex task of academic writing into discrete phases (Predict, Observe, Explain, and Write) the POEW model potentially reduces extraneous cognitive load, allowing learners to devote cognitive resources to generating content and organizing ideas before attending to linguistic accuracy. This gradual release of cognitive demands is particularly beneficial for L2 writers in ESP settings, who must simultaneously manage language proficiency and content knowledge. Furthermore, writing assessment frameworks such as the ESL Composition Profile (Jacobs et al., 1981) highlight the multifaceted nature of writing competence, encompassing content, organization, vocabulary, language use, and mechanics, all of which are directly relevant to the demands faced by Biology Education students. Contemporary formulations of Cognitive Load Theory emphasize designing complex tasks so that unnecessary processing is minimized while cognitive resources are directed toward schema construction and task-relevant reasoning (Sweller et al., 2019; Paas & van Merriënboer, 2020). More recent work also cautions that instructional supports should be evaluated in context because features that add processing demands may still promote engagement or learning when they are functionally integrated (Skulmowski & Xu, 2022).

Ecological themes are particularly suitable for integrating POEW with ESP writing because they combine observable phenomena, visual representations, and societally relevant problems. Reviews of environmental and climate-change education show that active, inquiry-oriented experiences can strengthen knowledge, attitudes, and conservation-related outcomes, especially when learners work with locally meaningful issues and evidence (Ardoin et al., 2018; Ardoin et al., 2020; Monroe et al., 2019). In the present study, ecology therefore functions not only as topical content but also as a disciplinary context for linking observation, explanation, and academic writing.

The present study addresses the identified gap by piloting an ecological-themed POEW model in an English for Biology course at an Indonesian university. Given the small sample size and the absence of a control group, this investigation is explicitly positioned as a pilot mixed-methods repeated-measures study aimed at generating hypotheses rather than establishing definitive causation. Two research questions guide the inquiry: (1) How do Biology Education students' academic writing scores change across four measurement points after learning through the ecological-themed POEW model? (2) How do students perceive the use of the ecological-themed POEW model in English for Biology academic writing?

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2. Methods

2.1 Study Design

This pilot study employed a mixed-methods design, combining a one-group repeated-measures quantitative component with a qualitative interview component. This design was selected to obtain preliminary empirical evidence on the ecological-themed POEW model in an authentic English for Biology classroom. The quantitative component measured academic writing performance at four time points: pretest (T1), midtest (T2), posttest (T3), and two-week follow-up (T4). The qualitative component explored students' perceptions of the learning process, including its benefits and challenges. Given the inherent threats to internal validity associated with one-group designs (e.g., history, maturation, and testing effects), this study is explicitly framed as exploratory; findings should be interpreted with due caution and are intended to inform larger-scale confirmatory research.

2.2 Setting and Participants

The study was conducted at Universitas Muhammadiyah Parepare, Indonesia, during the even semester of the 2023/2024 academic year. The instructional context was an English for Biology course that met twice per week for 100 minutes per session. The participants were eight second-semester Biology Education students who were enrolled in the course. Purposive sampling was used with four inclusion criteria: active enrollment in English for Biology, no prior experience with the POEW model, no prior training in inquiry-based academic writing, and willingness to participate in all research activities. All eligible students agreed to participate.

2.3 Intervention

The intervention consisted of four instructional meetings. Each meeting focused on one ecological theme and followed the Predict, Observe, Explain, and Write sequence. The themes and learning focus are shown in Table 1.

Table 1. Ecological Themes Used in the POEW Intervention

Meeting	Theme	Learning Focus
1	Ecosystem	Ecosystem components, ecosystem types, and ecological interactions
2	Food Chain and Food Web	Trophic levels, energy flow, and food-web relationships
3	Biodiversity	Species diversity, conservation status, and the importance of biodiversity
4	Environmental Issues	Pollution, climate change, and human impacts on ecosystems

During the *Predict* stage, students examined images, graphs, short prompts, or ecological data and wrote initial predictions about the topic. In the *Observe* stage, they read short academic texts or interpreted visual data to compare their predictions with evidence. During the *Explain* stage, students discussed the observed information, clarified vocabulary, and explained relationships between predictions and evidence. Finally, in the *Write* stage, students produced an academic paragraph of approximately 150 words. Feedback was provided after writing, and students incorporated it into their revisions.

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2.4 Data Collection

Academic writing performance was measured through paragraph-writing tests administered at T1, T2, T3, and T4. Each test required students to write one academic paragraph on an ecological topic. The writing samples were scored using the ESL Composition Profile (Jacobs et al., 1981), which assesses content, organization, vocabulary, language use, and mechanics on a total scale of 0 to 100. The rubric and interview guide were reviewed by two expert validators before use. An observation checklist was also employed to monitor fidelity of implementation for each POEW stage. After the posttest, semi-structured interviews were conducted with all participants to explore their learning experiences, perceived benefits, difficulties, and suggestions.

2.5 Data Analysis

Quantitative data were analyzed using SPSS version 22. Given the small sample and repeated measures, the Friedman test was employed to examine differences across T1, T2, T3, and T4. Kendall's W was reported as an effect-size estimate for the Friedman test. Pairwise comparisons were subsequently conducted using the Wilcoxon signed-rank test. Effect sizes for each Wilcoxon comparison were calculated as $r = |Z|/\sqrt{N}$, where N represents the eight paired observations; values of .10, .30, and .50 were interpreted as small, medium, and large effects (Cohen, 1988). Because effect-size estimates are unstable in very small samples, they are interpreted descriptively rather than as precise population estimates (Funder & Ozer, 2019; Lakens, 2022). Qualitative interview data were transcribed verbatim and analyzed thematically following Braun and Clarke's (2006) six-phase framework: familiarization, coding, generating themes, reviewing themes, defining and naming themes, and producing the report. The analysis also followed later guidance on reflexive thematic analysis, particularly the need for transparent documentation of coding decisions and coherence among the research questions, analytic procedures, and claims (Braun & Clarke, 2019, 2021). Quantitative and qualitative findings were integrated in the discussion to provide a comprehensive account of both outcome changes and student experiences.

2.6 Ethical Considerations

Students received an explanation of the study purpose, procedures, voluntary participation, confidentiality, and their right to withdraw. Written informed consent was obtained before data collection. Students' identities were anonymized in the report by using participant codes. Institutional permission was obtained from the study program before the classroom-based intervention.

3. Results and Discussions

3.1 Development of Academic Writing Scores

Table 2 presents descriptive statistics for students' academic writing scores across the four measurement points. The mean score increased from pretest to midtest, peaked at posttest, and then declined slightly at the two-week follow-up. Nevertheless, the follow-up mean remained substantially above both the pretest and midtest means.

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Table 2. Descriptive Statistics of Academic Writing Scores

Measurement	N	Mean	SD	Min	Max
Pretest (T1)	8	58.25	6.42	48	68
Midtest (T2)	8	67.50	5.89	58	76
Posttest (T3)	8	78.75	4.91	70	86
Follow-up (T4)	8	76.25	5.12	68	84

The upward trajectory from T1 to T3 suggests that repeated exposure to the POEW sequence facilitated idea generation and more coherent paragraph organization. Although the T4 score decreased slightly, it remained well above baseline.

The Friedman test confirmed a statistically significant difference across the four measurements, $\chi^2(3) = 18.75$, $p < .001$, Kendall's $W = .78$, indicating a large within-participant change in academic writing performance over the intervention period (Table 3).

Table 3. Friedman Test Result for Academic Writing Scores

N	χ^2	df	p	Kendall's W
8	18.75	3	< .001	.78

Wilcoxon signed-rank tests were conducted to identify specific pairwise differences (Table 4). The comparisons T1 vs. T2, T1 vs. T3, T1 vs. T4, and T2 vs. T3 were statistically significant. The T3 vs. T4 comparison was not statistically significant. Although the effect sizes (r) were large (ranging from .62 to .89), these values are likely inflated due to the very small sample and should be treated as preliminary estimates requiring replication.

Table 4. Wilcoxon Signed-Rank Pairwise Comparisons

Comparison	Z	p	r	Interpretation
T1 vs. T2	-2.201	.028	.78	Significant, large effect
T1 vs. T3	-2.521	.012	.89	Significant, large effect
T1 vs. T4	-2.394	.017	.85	Significant, large effect
T2 vs. T3	-2.201	.028	.78	Significant, large effect
T3 vs. T4	-1.751	.080	.62	Not significant

The strongest comparison was between T1 and T3, which indicates that students' writing performance improved most clearly by the end of the four POEW meetings. The significant T1 to T4 comparison suggests that the improvement did not disappear immediately after the intervention. However, the non-significant T3 to T4 comparison should be interpreted carefully. It does not prove long-term retention; it only shows that the two-week follow-up score was not statistically different from the posttest score in this small sample.

3.2 Students' Perceptions of the POEW Model

Thematic analysis of the interviews produced three themes: vocabulary and pronunciation support, improved paragraph organization and idea mapping, and challenges during the prediction stage. These themes are summarized in Table 5.

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Table 5. Summary of Thematic Findings

Theme	Sub-Aspect	Key Finding	Representative Quotation
Vocabulary & pronunciation support	Ecological vocabulary and pronunciation	Repeated exposure to ecological terms facilitated meaning recognition and pronunciation.	"*Kita bisa lebih banyak mengetahui jenis kata tentang ekologi dan artinya, serta pengucapannya*." (We could learn more ecological vocabulary, its meanings, and pronunciations.)
Improved paragraph organization & idea mapping	Sentence construction, paragraph flow, and idea mapping	The Observe stage helped students collect ideas prior to writing and arrange them logically.	"*Dengan cara mengamati terlebih dahulu, kemudian mengumpulkan ide-ide yang dilihat, saya jadi lebih mudah menyusun paragraf*." (By observing first and then gathering ideas from what I saw, it became easier to compose paragraphs.)
Challenges during prediction	Limited vocabulary and cognitive demand	Students struggled to express predictions due to limited English ecological vocabulary.	"*Awal-awal agak sulit di tahap prediksi karena tidak terlalu tahu kata-kata tentang ekologi*." (It was somewhat difficult at the prediction stage because I did not know enough ecological terms.)

The first theme underscores the model's utility in promoting vocabulary acquisition within a disciplinary context—a key consideration for ESP pedagogy. The second theme indicates that the Observe stage served as a crucial cognitive bridge, reducing the difficulty of initiating the writing process. The third theme, however, highlights a critical pedagogical implication: vocabulary scaffolding is essential before the Predict stage, as insufficient lexical resources may impede effective prediction and engagement. This interpretation is consistent with research showing that disciplinary vocabulary is central to successful academic writing and cannot be treated as an interchangeable list of general academic terms (Durrant, 2016; Hyland, 2022).

The second theme concerns writing development. Students reported that the Observe stage made writing easier because they could gather ideas from texts, images, or data before composing paragraphs. This finding explains why scores may have improved across the intervention. The POEW sequence did not ask students to write immediately. It gave them a thinking path: activate prior knowledge, verify it through observation, discuss explanations, and then write. This path reduced the difficulty of starting a paragraph and helped students organize ideas more coherently. This process resembles writing-to-learn practices in science, in which students transform observations and disciplinary information into organized explanations (Moon et al., 2018; Gere et al., 2019).

The third theme highlights the main challenge. Some students found the Predict stage difficult because their ecological vocabulary in English was limited. This challenge

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does not weaken the usefulness of POEW, but it shows that the model requires scaffolding. If students do not have enough initial vocabulary, prediction may become a source of anxiety rather than a productive thinking activity. Short vocabulary previews, pronunciation drills, and model sentences before prediction can make the first stage more accessible. Such pre-task scaffolding can reduce avoidable processing demands and make genre expectations more visible before students undertake the cognitively demanding prediction task (Nagao, 2019; Paas & van Merriënboer, 2020; Sweller et al., 2019).

4. Discussion

The quantitative and qualitative findings converge to provide a coherent narrative. The significant score gains suggest that the ecological-themed POEW intervention was associated with improvements in academic writing performance. The interview data help elucidate these gains: students benefited from the structured progression from prediction through evidence to writing. This progression aligns with constructivist principles, enabling students to build understanding through active engagement rather than through isolated grammar instruction. The pattern is also consistent with writing-to-learn research in STEM, which suggests that writing supports conceptual development when learners transform disciplinary evidence into explanations rather than copy information (Reynolds et al., 2012; Gere et al., 2019).

In line with Susilawati (2023) and Montoya (2023), the findings are consistent with research showing that content-language integration can support writing when disciplinary and linguistic objectives are explicitly coordinated (Goris et al., 2019; Graham et al., 2018). The result also supports calls for academic literacy instruction to be embedded in disciplinary curricula rather than treated as generic language remediation (Wingate, 2018; Hyland, 2022). However, unlike studies employing broad CLIL-oriented tasks, the present investigation suggests that a specific staged inquiry sequence (POEW) may provide a structured cognitive pathway for content-based writing. The significant improvement from T1 to T3 ($Z = -2.521$, $p = .012$) echoes the positive effects of POEW reported by Sianna and Syawal (2017) in general writing contexts; the present findings extend that work to discipline-specific ESP writing in biology, where students must process scientific content before producing academic text.

Unlike Tekindur and Kingir (2024), who focused on argument-based inquiry to improve elementary students' scientific writing, the current study targets tertiary-level ESP learners and employs ecological themes as both content input and writing stimuli. This difference in educational level and disciplinary focus explains why vocabulary scaffolding emerged as a critical concern in our qualitative data, whereas vocabulary was less prominently discussed in studies with younger learners or native speakers. The cognitive challenge reported by students during the Predict stage (due to limited ecological vocabulary) is consistent with Cognitive Load Theory (Sweller, 1988), which predicts that insufficient prior knowledge increases intrinsic cognitive load, thereby hindering the prediction process. This finding explains why the effect, while significant,

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may not be as robust as in studies where learners possess greater content familiarity. Vocabulary scaffolding therefore emerged as a critical condition, consistent with evidence that disciplinary lexical demands can constrain academic writing performance and confidence among multilingual writers (Durrant, 2016; Flowerdew, 2020; Zotzmann, 2021).

The follow-up mean remained above baseline, but the non-significant T3-T4 comparison ($Z = -1.751$, $p = .080$) should not be treated as evidence of equivalence or long-term retention. Statistical significance alone is an insufficient basis for substantive conclusions, particularly in a very small exploratory sample (Wasserstein et al., 2019). The pattern is therefore best described as preliminary short-term maintenance requiring replication. Moreover, the absence of a control group means that alternative explanations, including repeated practice, instructor effects, or concurrent course activities, cannot be ruled out.

The effect sizes observed in this pilot study ($r = .62$ to $.89$) are larger than those commonly expected in educational interventions, but they should not be interpreted as precise population effects. Very small samples produce unstable estimates and substantial uncertainty, even when standardized effects appear large (Funder & Ozer, 2019; Lakens, 2022). The novelty of the POEW sequence may also have produced a temporary engagement effect. Future research with larger, more heterogeneous samples and longer intervention periods is therefore essential to determine whether the observed pattern is replicable.

4.1. Strengths, Limitations, and Implications

This study presents several strengths. First, the repeated-measures design allowed for tracking of writing development across time, rather than relying solely on pre- and posttest comparisons. Second, the mixed-methods approach integrated outcome data with experiential accounts, enriching the interpretation of findings. Third, the inclusion of a follow-up measurement, albeit brief, provided initial insight into the sustainability of observed improvements.

Nevertheless, several limitations must be acknowledged. The sample size ($N = 8$) is extremely small, severely limiting generalizability and inflating effect size estimates. The one-group design lacks a control condition, making it impossible to attribute improvements definitively to the POEW intervention. The study was conducted at a single university within a specific course, further limiting external validity. Moreover, inter-rater reliability for the writing scores was not reported, representing a significant methodological gap. The follow-up period of two weeks is insufficient to draw conclusions about long-term retention. Finally, the absence of independent raters may introduce scorer bias. The qualitative component was also based on a small, context-bound dataset; accordingly, the themes are presented as interpretive patterns rather than frequency-based generalizations, consistent with reflexive thematic-analysis guidance (Braun & Clarke, 2019, 2021).

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The practical implications for ESP pedagogy are nonetheless noteworthy. Lecturers teaching academic writing to science education students may consider adopting the POEW sequence, provided they implement robust vocabulary scaffolding prior to the Predict stage. Ample time should be allocated to the Observe stage, as students rely on this phase to gather content and organize their paragraphs. Authentic ecological materials, such as diagrams, short scientific texts, localized environmental cases, and simplified data displays, can strengthen the connection between scientific reasoning and academic writing. This recommendation is consistent with environmental-education reviews emphasizing active engagement with meaningful evidence and locally relevant problems (Ardoin et al., 2018; Ardoin et al., 2020; Monroe et al., 2019).

Future research should address the limitations of this pilot study by employing larger samples, randomized controlled or quasi-experimental designs, independent raters with established inter-rater reliability, and extended follow-up periods. Comparative studies examining POEW against process writing or genre-based approaches would also be valuable, as would investigations into the model's effects on specific writing sub-components (content, organization, vocabulary, language use, and mechanics) in various ESP domains.

5. Conclusion

The study indicates that ecological-themed POEW offers a promising pedagogical bridge between scientific inquiry and ESP academic writing. The increase in students' writing scores from pretest to posttest, together with qualitative reports of improved vocabulary recognition and paragraph organization, supports the potential viability of this staged model in an English for Biology course. The follow-up mean remained above baseline after two weeks, but this pattern should be interpreted as preliminary rather than as evidence of long-term retention. The identified challenge—limited vocabulary during the prediction stage—underscores the need for targeted vocabulary scaffolding before students engage in prediction tasks. Theoretically, the study contributes to ESP research by connecting Cognitive Load Theory with inquiry-based writing pedagogy. Practically, it offers a replicable four-phase instructional sequence for EFL lecturers teaching scientific writing. Given the pilot design, small sample, and absence of a control group, the findings are exploratory and hypothesis-generating. Confirmatory studies with larger, more diverse samples, rigorous comparison conditions, longer follow-up periods, and independent scoring are required to establish the generalizability of the POEW model across ESP contexts.

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Author Contributions

All authors contributed to the conception, design, implementation, data analysis, and manuscript preparation.

Conflicts of Interest

The authors declare no conflict of interest. The funders had no involvement in the study design, data collection, data analysis, interpretation, manuscript preparation, or publication decision.

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