

Development of Ecolinguistic-based Digital Comic Learning Media Using the ADDIE Framework to Enhance Environmental Literacy

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Abstract—Environmental literacy among elementary school students in Indonesia remains low due to the limited use of creative and contextually relevant digital media in classroom learning. This study addresses this issue by developing the Ecolinguistic-Based Electronic Environmental Comic (E-Coming) as an innovative learning medium that integrates ecological values, language use, and local cultural narratives. The specific novelty of this study lies in the operationalization of ecolinguistics as a pedagogical and linguistic design framework for digital comics, rather than treating it solely as thematic environmental content. The study employed the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) instructional design framework, consisting of the stages of Analysis, Design, Development, Implementation, and Evaluation, and was conducted in several elementary schools in Semarang, Indonesia. A total of 104 students and 10 teachers participated in the needs analysis, expert validation, and classroom implementation stages. Expert evaluation confirmed the high validity of the media, with an average score of 95.5 percent classified as Excellent and a Content Validity Index of 1.00. Classroom implementation results indicated meaningful improvements in students' environmental literacy, with learning outcomes increasing across cognitive, affective, and behavioral dimensions, as reflected by a moderate N-Gain score of 0.57. In addition, the media achieved a high user acceptance rate of 93.6 percent, indicating strong usability and engagement. These findings indicate that integrating ecolinguistic principles into digital comic-based learning media can support short-term improvements in environmental literacy and initial ecological awareness through language-driven and culturally grounded narratives, contributing to Education for Sustainable Development in elementary education. As a Research and Development study with a non-experimental design, the findings reflect short-term instructional outcomes rather than long-term behavioral or causal effects.

Keywords—digital learning media; Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model; ecolinguistics; environmental literacy; primary education

I. INTRODUCTION

This project focuses on incorporating ecolinguistics principles into digital learning medium to improve environmental literacy among elementary school children. It specifically looks at how language-driven narratives, cultural expressions, and ecological implications might be included in digital comics as a teaching tool for sustainability education.

Weaving together the study of language, culture, and ecology into interactive visual narratives created for young learners is one way to incorporate ecolinguistics principles into digital comic-based learning materials [1]. When

included in educational media, ecolinguistics, which studies how language reflects and influences our interaction with the natural world, can increase students' knowledge of environmental issues [2]. In line with the current expectations for digital literacy in primary school, digital comics provide a multimodal platform that combines text, images, and interaction.

Despite the growing global focus on environmental education and sustainability, many elementary schools continue to use static print materials and traditional teaching methods that lack interactivity, cultural relevance, and explicit integration of language ecological linkages [3]. Studies undertaken in Indonesian educational contexts show that elementary school pupils' environmental literacy remains relatively low, owing in part to learning tools that do not fully engage local cultural contexts or use interactive digital formats [4]. This circumstance emphasizes the importance of novel learning media that integrate language awareness, digital technology, and ecological education in a consistent manner [5].

Previous research has found that using e comics and digital comics to enhance environmental literacy produces favorable results. For example, digital comics based on folktales and local wisdom have been demonstrated to improve primary school students' Eco literacy [6]. Other research used digital comics to promote cultural and civic literacy and found significant learning benefits among elementary school students [7]. However, most of this research focuses on visual design and narrative content, whereas the systematic use of ecolinguistics as a theoretical and analytical framework remains limited [8]. As a result, the impact of language, discourse, and ecological meaning creation in developing students' environmental awareness via digital media has not been thoroughly investigated.

Because ecolinguistics offers a theoretical framework for comprehending how linguistic decisions, metaphors, and culturally grounded narratives impact ecological worldviews and pro-environmental action, this research gap is crucial. However, there are presently few empirical studies that explicitly apply ecolinguistic principles to the development and assessment of digital learning materials for elementary education.

This study addresses the limited availability of interactive and culturally grounded digital media for environmental education in elementary schools. It aims to develop an ecolinguistically informed digital comic to support students'

environmental literacy in a primary education context.

The purpose of this study is to investigate the validity, effectiveness, and user acceptance of the proposed ecolinguistics-based digital comic learning media, as well as its potential contribution to developing students' environmental literacy across cognitive, emotional, and behavioral dimensions. The findings are likely to help build teacher-ready instructional material that promotes the integration of ecological education, linguistic awareness, and digital technology in elementary school learning contexts [9].

II. LITERATURE REVIEW

Although previous studies have demonstrated the effectiveness of digital comics in supporting environmental literacy, most have focused on narrative or visual aspects without employing an explicit ecolinguistic or discourse-based analytical framework, indicating a gap in current research.

The theoretical and empirical underpinnings of the creation of ecolinguistics digital comics for environmental literacy and green economy instruction in elementary schools are thoroughly reviewed in this part. The discussion summarizes earlier research as well as the main ideas that underpin this investigation. The relationship between ecolinguistics and environmental literacy in education, the use of digital comics as learning media in primary education, the incorporation of green economy concepts into learning design, and the use of instructional design models, specifically the ADDIE framework, in the creation of innovative educational media are the four main subtopics that comprise the review. These subsections together establish the conceptual foundation for the design and implementation of *El Coming* as an ecolinguistic based digital learning medium that promotes sustainability-oriented learning among young students.

A. Ecolinguistics and Environmental Literacy in Education

Ecolinguistics examines how language, culture, and the environment interact, with a focus on how linguistic expressions affect people's ecological consciousness and actions [10]. Ecolinguistics offers a paradigm for incorporating environmental principles into education through speech, metaphors, and stories that depict sustainable interactions with the natural world [11]. Language impacts learners' environmental ethics and responsibility in addition to being a tool for communication [12]. When ecolinguistic education is implemented at the primary school level, it strengthens environmental literacy by assisting pupils in interpreting ecological realities through contextual and culturally appropriate language use [13].

The ability to comprehend, evaluate, and properly address environmental issues is known as environmental literacy [14]. It includes behavioral, effective, and cognitive skills that allow people to engage in sustainable practices [15]. Thus, incorporating ecolinguistics into environmental education strengthens students' ability to express and absorb green ideas in real-world situations by bridging linguistic awareness with ecological consciousness [16]. Research indicates that pupils show more empathy for the environment and are more inclined to act in an environmentally responsible manner when ecological ideals are communicated through culturally grounded

language patterns [17].

Building on the relationship between language, ecology, and environmental literacy, the next paragraph explains how digital comics might be used as a multimodal learning tool to implement ecolinguistics concepts in primary school.

B. Digital Comics as Learning Media in Primary Education

Digital comics are a type of multimodal learning media that generate meaningful educational experiences by fusing text, graphics, and interactive elements [18]. By converting abstract concepts into more comprehensible visual narratives, particularly for elementary school students, they encourage student participation. Because digital comics activate both visual and linguistic cognitive channels, research suggests that they improve reading comprehension, vocabulary development, and conceptual understanding.

Through relatable stories, comic-based learning materials can successfully communicate social values and ecological concerns in the context of environmental education [19]. Digital comics incorporate comedy, interaction, and visual storytelling, making them appropriate for raising young students' knowledge of environmental issues [20]. They enable teachers to create contextual learning opportunities that link concepts learned in the classroom to contemporary problems like sustainability, waste management, and renewable energy [21]. Interactive digital comics based on local knowledge have been shown in numerous studies to greatly enhance students' motivation and academic performance. Therefore, digital comics are a cutting-edge teaching medium that fits with contemporary educational paradigms that prioritize digital literacy, creativity, and critical thinking [22].

Digital learning materials not only promote a basic understanding of the environment but also strategically introduce sustainability-focused ideas like the green economy, which expands environmental literacy into the realm of responsible economic decision-making.

C. Green Economy in the Educational Context

Green economy literacy places more emphasis on long-term sustainability, responsible production and consumption, and well-informed economic decision-making that strikes a balance than environmental, social, and economic factors than does general environmental awareness.

An economic system that greatly lowers environmental dangers and ecological scarcity while promoting social justice and human well-being is known as the "green economy." In the context of education, green economy literacy entails comprehending the relationship between economic activity and environmental sustainability as well as how ethical production and consumption can support long-term ecological balance [23]. Building early understanding of sustainability challenges and motivating pupils to embrace eco-friendly behaviors like recycling, energy conservation, and trash reduction need the integration of green economy ideas into elementary education [24].

Green economy themes can be conveyed through interactive learning materials like *El-Coming* that use language and images that are relevant to students' local and cultural contexts [25]. These economic concepts can be conveyed through narratives that link moral principles, cultural identity, and ecological responsibility thanks to the

ecolinguistic perspective [26]. In addition to fostering environmental literacy, this integration equips young students to engage in sustainable economic behaviors in the future [27].

To systematically integrate ecolinguistic principles and green economy concepts into digital learning media, an instructional design framework is required, which is discussed in the following subsection.

D. Instructional Design Models for Digital Learning Media (ADDIE Framework)

The ADDIE model consists of five systematic stages, namely Analysis, Design, Development, Implementation, and Evaluation. It is a widely recognized instructional design framework used to develop effective educational media. The model provides an organized and iterative process that ensures learning products meet user needs and achieve measurable learning outcomes [28]. In the context of the El Coming project, the ADDIE framework serves as the main design and production guide for developing ecolinguistics based digital comics. The process begins with a needs analysis conducted in several primary schools in Semarang, Indonesia, followed by the design of instructional and visual components that reflect ecolinguistics principles [29]. During the development stage, the prototype comic is created with interactive and multimedia features, while the implementation stage focuses on classroom application and user feedback. The final stage, evaluation, involves both formative assessment during production and summative assessment after deployment to measure effectiveness and user satisfaction [30].

Each phase of the ADDIE model requires user participation, expert validation, and iterative refinement. Therefore, the framework significantly enhances the validity and reliability of educational innovations [31]. This structured approach ensures that the media produced are both technically feasible and pedagogically sound. Several previous instructional development studies have reported high expert validation scores when applying the ADDIE model, indicating its suitability for developing structured and pedagogically sound learning media [32]. The El Coming development process follows the same principle through continuous improvements based on teacher and student feedback. As a result, the final product is not only visually engaging and easy to use but also contextually relevant to the objectives of ecolinguistics based environmental literacy education in primary schools [33].

III. MATERIALS AND METHODS

The design, development, and assessment of El-Coming (Electronic Environmental Comic), a digital learning tool that incorporates ecolinguistics concepts to improve elementary children's environmental literacy, are described in this part. The study was carried out using a Research and Development (R&D) paradigm that prioritized user-centered design and iterative validation. To guarantee that the finished product satisfied both pedagogical and technical criteria, the procedure adhered to the ADDIE instructional design model, which consists of the Analysis, Design, Development, Implementation, and Evaluation stages. To ensure ecological relevance, linguistic accuracy, and usability in school

settings, each step was meticulously documented, engaging educators, students, and experts.

The pretest and post test instruments were designed to assess environmental literacy dimensions that were conceptually aligned with the ecolinguistic indicators embedded in the digital comic design. Each test item reflected key ecolinguistic elements such as ecological relationships human nature responsibility and evaluative language toward environmental actions allowing the measured learning gains to be interpreted in relation to the ecolinguistic features of the media.

A. Research Design

The main methodological and instructional design paradigm used in this study is the ADDIE framework. Although all development activities are clearly planned and interpreted in accordance with the five ADDIE phases Analysis, Design, Development, Implementation, and Evaluation, the research is carried out using research and development strategy. Rather than being a distinct methodological framework, the nine operational development steps procedures are operational elaborations inside these ADDIE phases.

The methodical creation of El-Coming as a digital learning platform based on ecolinguistics principles was guided by the ADDIE instructional design methodology (Analysis, Design, creation, Implementation, and Evaluation). Because it is iterative and user-centered, the ADDIE paradigm was chosen to guarantee that the material created is both technically sound and pedagogically effective [34]. Each phase of the ADDIE model was carried out sequentially yet adaptively, allowing feedback from experts, teachers, and students to inform subsequent refinements. This systematic approach ensured that the resulting media not only met design standards but also aligned with the ecological and cultural contexts of elementary education.

This study employed a Research and Development approach as the overarching research paradigm, focusing on the systematic design, validation, and implementation of instructional media. The development process was guided by the ADDIE instructional design model, which consists of five core phases: Analysis, Design, Development, Implementation, and Evaluation. To ensure operational clarity and practical feasibility in classroom settings, each ADDIE phase was further elaborated into nine concrete development steps. These nine steps do not constitute an independent development model but rather serve as technical operationalizations of the ADDIE framework. Accordingly, the methodological structure of this study follows a clear hierarchy in which Research and Development functions as the research paradigm, ADDIE serves as the instructional design model, and the nine steps procedure operates as its practical implementation. Within this framework, the study adopted a mixed method strategy by integrating quantitative validation techniques including the Content Validity Index, N Gain analysis, and user acceptance index with qualitative exploration through needs analysis and expert review. The operational implementation of the ADDIE phases, along with the associated activities, procedures, and resulting artifacts, is systematically presented in Table 1 [35].

All activities were carried out with previous parental and

school approval. Aggregated statistics were utilized for reporting, and student data was anonymized. Academic grades were unaffected by participation; it was entirely voluntary.

Table 1. The ADDIE framework and artifact flow for El-Coming

ADDIE Phase	Main Activities	Output/Artifacts
Analysis	• Need analysis conducted in three public elementary schools in Region X (coded as Schools XYZ 01, XYZ 02, and XYZ 03).	Needs-analysis report, learner-profile summary, curriculum-media matrix.
	• Identify students' and teachers' needs (visual, interactive, audio).	
	• Curriculum mapping for the theme "Sayangi Bumi."	
Design	• Storyboard, script, and ecolinguistic message development.	Storyboard document, dialogue scripts, user-interface layout.
	• UI wireframe and navigation design.	
	• Learning-objective mapping.	
Development	• Digital illustration using Clip Studio Paint.	Alpha and beta prototypes, validator rubrics, revision logs.
	• Integration of HTML5, audio, and interactivity.	
	• Expert validation (content, language, and media).	
Implementation	• Classroom trial at Public Elementary School XYZ 04.	Field notes, student responses, pre- and post-test data.
	• Usage scenario planning and teacher facilitation.	
	• Expert validation (CVI = 1.00).	
Evaluation	• Effectiveness testing (N-Gain = 0.57).	Final version of El-Coming, evaluation report.
	• User acceptance (93.6%).	
	• Final improvement and revisions.	

B. Media Development Process

El-Coming was developed in accordance with the structured steps of the ADDIE model, which are Analysis, Design, and Development. These phases were carried out in a sequential and iterative manner before moving on to the

stages of implementation and assessment. To promote environmental literacy in elementary education, these phases combined linguistic, visual, and technical components to transform the conceptual framework of ecolinguistics into a concrete instructional media product.

Table 2. Ecolinguistic indicators of the comic (unified version)

No	Aspect	Linguistic / Ecolinguistic Indicator	Operational Description (Based on Comic Content)	Related Environmental Literacy Dimension Assessed
1	Representation of Ecological Relations	Human-nature relationship	Characters (Sila, Yaya, Raka, Sari) are depicted as having cause-effect interactions with environmental conditions (waste, pollution, deforestation).	Ecological knowledge and understanding of human-nature relationships
		Nature as a living subject	The character "Nature" is portrayed as a guardian of the earth; rivers, trees, and the sky are personified as living entities.	
		Ecological interdependence	The story presents interconnections such as waste-air-river, sunlight-solar panels-electricity needs, trees-soil-landslides, and factory pollution-health.	
2	Ecological Language Choices	Ecological lexicon	Use of terms such as: "recycling," "solar panels," "green economy," "supporting trees," "smoke filters," "pollution," and "clean energy."	Environmental awareness and evaluative understanding of environmental actions
		Ecological metaphors	Expressions such as: "The sky is the mirror of the earth's heart," "The earth is protesting," "Waste can become a blessing," and "Trees plant hope."	
		Anti-exploitative stance	Rejection of waste burning, excessive plastic use, and forest exploitation.	
		Beneficial ecological stories	Encouraging waste sorting, tree planting, renewable energy usage, natural packaging, and pollution reduction.	
3	Environmental Ideology (Stibbe — Stories We Live By)	Destructive stories (criticized)	Waste burning, excessive plastic consumption, factory pollution, and uncontrolled deforestation.	Environmental responsibility orientation and ethical judgment
		Relationship stories	Emotional bonds with nature: grandfather's advice, Sila's conversation with Nature, and community-environment relations.	
		Identity stories	Children are positioned as ecological change agents.	
		Conviction stories	Use of Javanese expressions: "resik-resik panguripan," "wong kang nandur bakal ngundhuh," "Nandur saiki, ngicipi seger sesuk."	
4	Ecological Actions	Direct ecological actions	Planting trees, sorting waste, creating recycling corners, using solar panels, and installing factory filters.	Conceptual understanding of pro-environmental actions and sustainable practices
		Collective action	Tree adoption programs, plastic-free market campaigns, community meetings, and school-based environmental education.	
		Sustainable action	Long-term behavioral changes: green markets, cleaner villages, renewable energy initiatives, and long-term reforestation.	
5	Aspect	Linguistic / Ecolinguistic Indicator	Operational Description (Based on Comic Content)	-

A needs assessment was conducted at three public primary schools in Region X (marked as Elementary School X1, Elementary School X2, and Elementary School X3) to start the analytical phase. Ten Grade 4 teachers and 104 students participated, and their answers gave a thorough grasp of the learning environment. The results showed that 76% of students preferred interactive visual media over traditional printed textbooks, while 82% of teachers had never used any digital learning materials with environmental themes. These findings informed several key design requirements for the forthcoming product: (i) readable typography with strong color contrast, (ii) interactive navigation features (tap, click, scroll), (iii) audio narration to assist comprehension, (iv) integration of local-culture expressions and ecolinguistic framing, (v) offline operability for low-connectivity regions, and (vi) curriculum alignment with environmental-education themes such as *reduce-reuse-recycle*, energy efficiency, waste segregation, and school-based sustainability practices.

Based on the findings of the needs analysis, El-Coming's pedagogical, linguistic, and interface structures were built during the design and development stages. The five domains (cognitive, affective, psychomotor, social, and environmental) that comprised the learning objectives targeted both behavioral awareness and conceptual comprehension [36]. Culturally grounded idioms and narratives that encouraged ecological responsibility were used to embed ecolinguistic elements [37], and the storyboard's problem-action-reflection sequence was reinforced by an easy-to-use interface with color schemes that

represented environmental harmony and clear navigation [38].

Before beginning the ecolinguistic discourse analysis of the comic, a set of operational indicators was created to systematically identify how ecological meanings are expressed through story structure, linguistic choices, character interactions, and visual features. These indicators were developed using ecolinguistic theory and Stibbe's Stories We Live By framework, then modified through expert validation to ensure conceptual clarity. Table 2 categorizes the indicators into four primary ecolinguistic dimensions: ecological relations, ecological language choices, environmental ideology, and ecological acts, each with full operational descriptions based on the comic's content.

Using HTML5 and Clip Studio Paint, the original design was turned into a working prototype that produced an interactive comic that could be used both online and offline. A beta version with five story arcs (My Trash, My Responsibility; Energy from the Sun; Mr. Raka's Green Market; Planting Trees, Planting Hope; and Grey Clouds over District X.) that emphasize local ecological values and accessibility through optimized typography, WCAG-compliant contrast, and audio narration was created after the initial alpha version was reviewed by experts.

The three stages mentioned above (analysis, design, and development) were converted into a more detailed nine step production process that integrated pedagogical, technical, and artistic aspects of the creation of the digital comic. Table 3 summarizes this comprehensive process.

Table 3. Detailed production steps of El-Coming digital comic development

No	Development Stage	Main Activities	Output/Product	Relation to ADDIE Model
1	Analysis of Learning Needs and Context	Identified learning issues related to the "Sayangi Bumi" (Love the Earth) theme, analyzed student characteristics (age, interest, reading skill, and digital literacy), and examined curriculum competencies.	Needs-analysis report including user characteristics and curriculum mapping.	Analysis—Basis for determining content and media design.
2	Storyboard Development (Script and Narrative Structure)	Composed storylines based on the analysis results, formulated ecolinguistic messages and green-economy values, and created panel-by-panel storyboard drafts.	Complete storyboard and narrative script for digital production.	Design—Planning of content, message, and structure.
3	Rough Sketching	Produced rough sketches from storyboards; determined panel composition, character position, and background; ensured logical visual sequence.	Rough-sketch compilation of the entire comic layout.	Design → Development—Transition from conceptual design to visual draft.
4	Revision of Characters, Language, and Layout	Adjusted characters to reflect local culture, refined dialogue language appropriate for Grade-4 literacy level, and improved text readability.	Clean-version draft (final sketches ready for coloring).	Development—Refinement based on expert feedback.
5	Coloring and Visual Enhancement	Applied digital coloring, shading, and lighting effects; aligned tone with environmental themes; improved aesthetic appeal.	Colored e-comics ready for publication.	Development—Digital-production stage.
6	Integration of Interactive Features	Added navigation buttons and simple audio/animation; optimized interactivity across devices.	Interactive e-comic file (HTML5/EPUB).	Development—Integration of interactivity and functionality.
7	Voice-Over/Dubbing	Wrote and recorded narration scripts; synchronized audio with visuals to support auditory learning.	Integrated audio files (MP3/WAV) in comic panels.	Development → Implementation—Preparation for classroom use.
8	Conversion to Application Format	Converted final comic to distributable digital formats (APK, HTML5, or e-learning platform), tested compatibility, and performed validation of media and language.	Final e-comic files are compatible with multiple platforms.	Implementation—Deployment for classroom testing.
9	Evaluation (Formative and Summative)	Conducted limited and large-scale usability tests; collected feedback from experts, teachers, and students; revised final product.	Evaluation report and finalized El-Coming product.	Evaluation—Formative and summative review of quality and effectiveness.

C. Implementation and Participants

Expert validation and field testing were conducted during the research's implementation phase to guarantee El-Coming's theoretical soundness and empirical usability as a teaching tool. To incorporate expert input prior to extensive testing, validation and classroom implementation were completed in a progressive manner. Five validators took part in the expert review, including two Grade 4 teachers who served as practitioner reviewers and three domain experts covering media/graphics, language, and content. A structured tool with 25 statements scored on a four-point relevance scale (1 = not relevant, 4 = highly relevant) was used by the validators to evaluate the prototype. Readability and typography, multimodal design and interaction, ecolinguistics appropriateness, content accuracy and curriculum alignment, and general classroom usefulness were among the assessment clusters. This validation aimed to measure how far the developed media met curricular objectives, linguistic clarity, and visual quality suitable for elementary students.

The validated version of El-Coming was used in an actual classroom setting to assess its usefulness after expert assessment and further modifications. Under the guidance of their class teacher, 104 Grade 4 pupils participated in the field implementation at SDN XYZ 04. Pre-tests were distributed to ascertain students' baseline comprehension of environmental concepts; El-Coming was used for a 40–60 min learning session in small groups using laptops or tablets; and post-tests, user-acceptance questionnaires, and brief teacher interviews were administered to gather qualitative feedback on usability and engagement.

The classroom implementation took place during a regular learning session lasting around 40 to 60 min. The class began with a brief teacher-led introduction (5–10 min) designed to awaken students' prior knowledge of environmental and sustainability issues. Students then spent around 20–30 min exploring the digital comic in small groups using tablets or laptops. During this activity, the teacher led discussions, clarified language, and helped students in reflecting on the narrative's ecological and green economy messages.

Following that, students engaged in a guided conversation (10–15 min) in which they communicated their comprehension, connected the subject to everyday activities, and debated pro-environmental behaviors. The session closed with a brief evaluation activity, followed by the distribution of post-tests and user satisfaction questionnaires.

Participants without consent or with incomplete data were not included in the dataset; only students who attended the entire session and completed all necessary instruments were. Every stage, from validation to classroom testing, was carried out methodically thanks to this sequential implementation, which guaranteed the validity of the results and the research's ethical integrity.

D. Data Analysis Techniques

An integrated quantitative and qualitative approach was used in this study's data analysis to assess the El-Coming learning media's validity, efficacy, and acceptance. Three analytical processes were carried out quantitatively: user acceptance study, media effectiveness analysis utilizing the N-Gain Score, and product validity analysis.

First, the Content Validity Index (CVI), which is derived from the following formula, was used to assess product validity [39]:

$$S - CVI = \frac{\text{Number of Valid Items}}{\text{Total Items}}$$

The media was categorized as valid when the S-CVI value was ≥ 0.80 . Second, the effectiveness of the media was determined by comparing students' pre-test and post-test scores using the *N-Gain* formula [40]:

$$g = \frac{(\text{Post test} - \text{Pre test})}{(\text{Maximum Score} - \text{Pre test})}$$

The effectiveness level was categorized as:

- $0.70 < g \leq 1.00$ = High
- $0.30 < g \leq 0.70$ = Medium
- $g \leq 0.30$ = Low

Third, the percentage calculation formula was used to examine user approval, which was obtained via teacher and student questionnaires [41]:

$$\text{Percentage} = \frac{\sum \text{Score}}{\sum \text{Maximum Score}} \times 100\%$$

The interpretation of acceptability followed these criteria:

- 81–100% = Highly acceptable
- 61–80% = Good
- 41–60% = Fair
- < 40% = Poor

In addition to quantitative techniques, a qualitative descriptive analysis was used to evaluate non-numerical data such as user demands, expert comments, teacher and student answers, and field observation notes. This procedure consisted of three steps: (1) data reduction, (2) data display, and (3) conclusion drawing.

This study presented a complete assessment of the El-Coming digital learning media's pedagogical, linguistic, and usability features by combining formula-based quantitative calculation and systematic qualitative interpretation.

This planned instructional process guaranteed that the assessed N-Gain value accounted for not just subject exposure but also directed interaction, reflection, and teacher facilitation during classroom implementation.

This study adopts a Research and Development (R&D) approach focusing on instructional media feasibility and short-term learning effectiveness rather than experimental hypothesis testing. Therefore, inferential statistical tests such as paired t-tests or effect size calculations were not applied. Learning effectiveness was evaluated using descriptive statistics and N-Gain analysis, which are commonly employed in instructional development studies to capture learning improvement within limited classroom interventions.

IV. RESULT

Fig. 1 depicts four typical interface presentations of the El-Coming digital comic to demonstrate the finished product. Panel (a) depicts the cover illustration, which introduces the main characters and the ecological topic with a bright environment and a youth-centered visual narrative. Panel (b)

displays the table of contents, which shows the structure of the five story chapters in a clear and orderly arrangement that makes it easier for young readers to navigate. (c) shows an example of a story page with character interaction, visual sequencing, interactive navigation buttons, and plot clues to help learners understand environmental signals inherent in the narrative. Although the speech bubbles feature local-language conversation, the page's primary purpose is to show how ecolinguistic elements are incorporated into the storyline

through character expressiveness, plot advancement, and contextual environmental events. Panel (d) depicts a collaborative tree-planting effort, stressing pro-environmental behavior, community participation, and experience learning as part of the story arc. Together, these panels illustrate how ecolinguistic elements are embedded in narrative structure, character interaction, and visual context, supporting the design objectives of environmental literacy-oriented digital learning media.

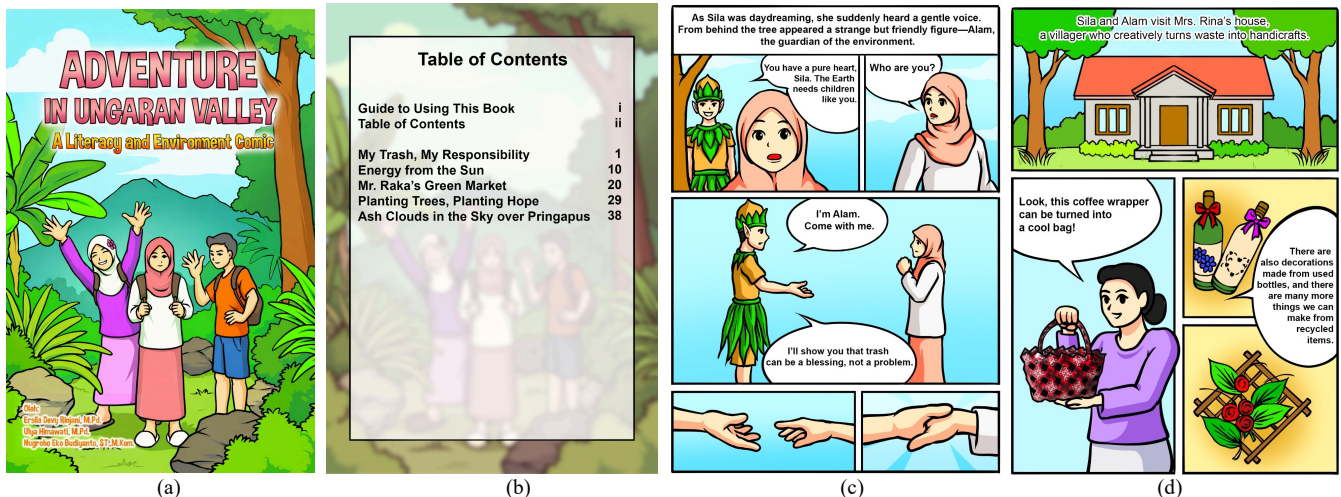


Fig. 1. Visual design of the El-Coming environmental literacy comic cover. (a) cover illustration; (b) table of contents; (c) story page with character interaction and interactive navigation elements; (d) page depicting a collaborative tree-planting scene.

A qualitative ecolinguistic discourse analysis was carried out to uncover the underlying environmental ideology inscribed in the dialogue of the comic to supplement the instructional and multimedia study. Table 4 presents representative dialogue snippets and the ecolinguistic interpretations that go along with them, based on Stibbe's Stories We Live By framework.

Although the ecolinguistic interpretations presented in Table 4 are grounded in established discourse theory, this

study did not include qualitative interviews or reflective responses to directly examine students' interpretations of ecological personification or culturally embedded metaphors. Therefore, the analysis represents theory-driven interpretations of the comic discourse rather than empirically verified learner perceptions. Future studies are encouraged to integrate student interviews or reflective writing tasks to triangulate ecolinguistic discourse analysis with learners' subjective understanding.

Table 4. Ecolinguistic interpretation of key dialogues in the comic

No	Dialogue Element	Example Dialogue from the Comic	Ecolinguistic Analysis
1.	Ecological personification	" <i>Sungai ini mulai sakit karena sampah...</i> " (The river is becoming sick because of the waste.)	The river is personified as a living being, constructing a beneficial ecological story that fosters environmental empathy.
2.	Ecological metaphor	" <i>Langit iku kaca ati bumi.</i> " (The sky is the mirror of the earth's heart.)	A Javanese metaphor portraying nature as a moral mirror of human behavior, strengthening ecological-cultural connections.
3.	Human–nature relation	" <i>Kalau dibakar terus, udara makin kotor...</i> " (If we keep burning it, the air will get dirtier.)	Shows cause-effect relations between human actions and ecological functions.
4.	Ecological identity	" <i>Kita mulai dari sekolah! Buat tempat sampah organik, anorganik, dan daur ulang!</i> " (Let's start at school by making organic, inorganic, and recycling bins!)	Positions children as ecological change agents → identity story.
5.	Pro-environment ideology	" <i>Besek lebih ramah bumi, Bu. Daun pisang itu budaya kita.</i> " (Bamboo baskets are more earth friendly. Banana leaves are part of our culture.)	Associates ecological practices with cultural identity → conviction story; critiques plastic consumption.
6.	Anti-exploitative stance	" <i>Longsor ini karena hutan kita tak lagi punya penyangga.</i> " (This landslide happened because our forest no longer has protective trees.)	Critiques deforestation, countering destructive ecological stories.
7.	Ecological action	" <i>Ayo tanam pohon, satu orang satu pohon!</i> " (Let's plant trees, one person one tree!)	Represents concrete ecological action through collective participation.
8.	Local ecological values	" <i>Wong kang nandur bakal ngundhuh.</i> " (Those who plant will later harvest.)	A Javanese proverb constructing a sustainability-oriented ecological ideology.
9.	Green economy perspective	" <i>Sampah bisa jadi berkah, bukan masalah.</i> " (Waste can become a blessing, not a problem.)	Reframes waste from destructive to productive, aligning with circular economic principles.
10.	Ecological collaboration	" <i>Kita ajak pabrik kerja bareng.</i> " (Let's collaborate with the factory.)	Highlights collaborative ecological harmony between industry and community.

The ecolinguistic discourse analysis was conducted through a systematic procedure consisting of four steps: (1) the cover illustration was used to identify initial representations of human-nature relationships and ecological framing at the introductory stage of the narrative; (2) the cover illustration was used to identify initial representations of human-nature relationships and ecological framing at the introductory stage of the narrative; (3) the story page with character dialogue was used as primary linguistic data for the ecolinguistic discourse analysis, particularly for identifying ecological metaphors, evaluative language, and personification of nature; and (4) the collaborative tree-planting scene was analyzed as a visual representation of beneficial ecological stories, illustrating collective ecological action and pro-environmental responsibility. Together, these visual components demonstrate how ecolinguistic indicators were operationalized across narrative structure, linguistic expression, and depicted actions, providing concrete units of analysis for the application of Stibbe's *Stories We Live By* framework.

The lexical selections shown in Table 5 serve as ecolinguistic tools that influence students' conceptions of environmental links rather than just being stylistic components. What ecolinguistic theory refers to as constructive ecological discourse, which fosters harmonious relationships between humans and nature, is reflected in words and expressions that emphasize interdependence, communal responsibility, and care.

From an ecolinguistic standpoint, such language promotes pro-environmental sentiments at a young age by framing ecological efforts as collective moral practices rather than personal obligations. By connecting ecological principles with students' everyday linguistic experiences, the use of culturally recognized phrases and metaphors strengthens this

effect even more.

These linguistic patterns, which are consistent with ecolinguistics discourse theory, support the development of students' initial ecological perspectives by influencing how learners comprehend environmental issues, assign responsibility, and reflect on sustainable practices. As a result, the discourse patterns observed in Table 5 show how language in digital comics can actively contribute to changing students' ecological perspectives rather than simply transmitting environmental knowledge.

Fig. 2 depicts the highest priority areas of the needs analysis. The bar chart reveals that clear drawings, readable writing, and curriculum-aligned information were the three most popular elements, with each garnering higher than 95% approval. Offline access and the inclusion of quizzes or short question-and-answer sessions were also heavily desired, illustrating users' need for both flexibility and active participation in learning media. These high percentages confirm that El-Coming's development requirements are closely aligned with actual user expectations, emphasizing the importance of incorporating strong visual design, contextual content, and interactive learning components in environmentally themed digital media for elementary learners.

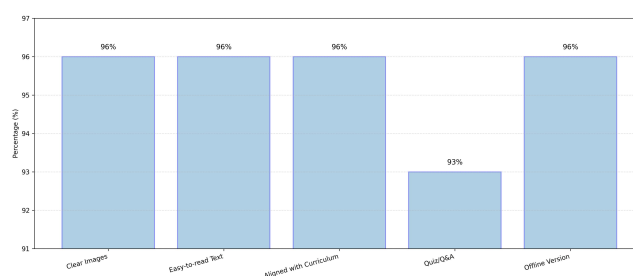


Fig. 2. Summary of respondents expectations.

Table 5. Needs analysis data for the development of the El-Coming ecolinguistic-based digital comic

Aspect	Item Statement	SA (%)	A (%)	N (%)	D (%)	SD (%)
El-Coming features	1. Text is easy to read	72	24	4	0	0
	2. Images are clear and colorful	75	21	4	0	0
	3. Contains animation features	70	26	4	0	0
	4. Interactive buttons (click/slide)	68	28	4	0	0
	5. Audio narration	65	30	5	0	0
	6. Variety of characters	71	25	4	0	0
	7. Contextual storyline	69	27	4	0	0
Content of material	8. Aligned with elementary curriculum	74	22	4	0	0
	9. Relevant to real-world problems	72	24	4	0	0
	10. Provides constructive solutions	70	26	4	0	0
	11. Inserts moral messages	73	23	4	0	0
Accessibility	12. Available as an application	66	28	6	0	0
	13. Accessible across multiple devices	68	26	6	0	0
	14. User-friendly interface	72	23	5	0	0
Expectations and Suggestions	15. Offline version available	70	26	4	0	0
	16. Includes quiz/Q&A	65	28	7	0	0
	17. Suggestions for further development	62	30	8	0	0

The expert validation results demonstrated that the El-Coming digital comic achieved a consistently high level of feasibility across all evaluated dimensions. As shown in Fig. 3, the highest scores were obtained in the categories of Digital Comic Design and Linguistic Quality, each reaching 97.5%. These findings show that the comic's visual composition, narrative clarity, and language structure were deemed highly appropriate for elementary school students by expert reviewers. Content Feasibility and Usability both obtained 95.5% ratings, indicating that the educational

materials are pedagogically relevant, accurate, and simple for students and teachers to use in real-world classroom situations. Although Interactivity & Multimedia received a slightly lower score of 92.5%, it remains in the "excellent" category, indicating that while the interactive components work well, there is still space to develop multimedia capabilities to increase user engagement. These data demonstrate that El-Coming material meets expert standards for quality, relevance, and educational efficacy. The distribution of expert ratings is illustrated in Fig. 3.

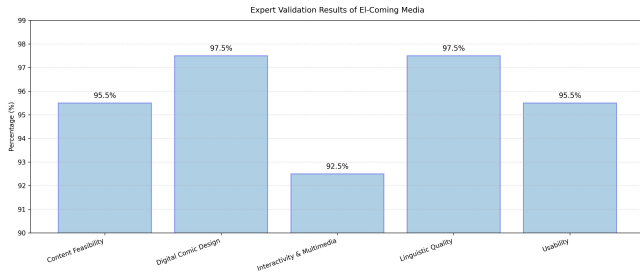


Fig. 3. Expert validation summary.

The scale validity analysis supported the robustness of the evaluation tool utilized in this study. As shown in Fig. 4, all 25 items had a Scale-Level Content Validity Index (S-CVI/Ave) of 1.00, demonstrating complete agreement among the validators on the relevance of each item. This number is significantly higher than the minimal validity criterion of 0.90, as seen by the dashed reference line in the picture. The consistently maximal scores across all items show that the instrument is extremely accurate in evaluating the desired constructions and has excellent relevance from both educational and linguistic viewpoints. These results confirm that the validator rating tool fits the specified requirements for high-quality evaluation tools and supports the dependability of the expert validation results.

Table 6 evaluation results reveal numerous crucial areas that need to be modified to improve the manuscript's overall quality, coherence, and scientific rigor. The most pressing difficulties (classified as Critical) were methodological consistency, ecolinguistic implementation, manuscript structure, and abstract completeness. These aspects serve as the paper's conceptual backbone; thus, clarity and alignment

are critical to properly communicating the study's design, methodology, and outcomes. Important modifications include strengthening the quality of references and citation style, improving figure and table presentation, and clearly defining the study's uniqueness. These components have a substantial impact on the manuscript's academic reputation, particularly in foreign journals where citation accuracy, visual clarity, and originality are key evaluation criteria.

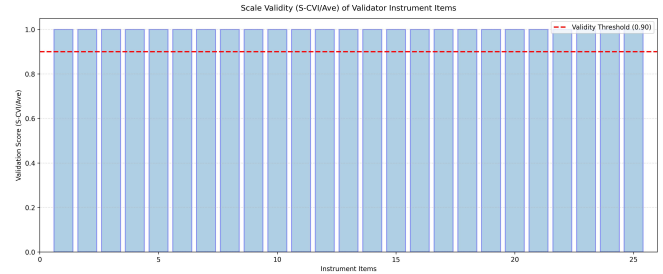


Fig. 4. Scale validity (S-CVI/Ave) of validator instrument items.

Moderate priorities prioritize classroom implementation specifics and language clarity. Although these shortcomings do not contradict the research's primary contribution, resolving them will increase readability and practical relevance. Clear structure and polished academic language ensure that the paper is understandable, scientifically valid, and pedagogically beneficial to a wider audience. The adjustments provided in Table 6 provide a disciplined roadmap for improving the manuscript's quality and guaranteeing compliance with international publication standards.

Table 6. Summary of identified issues, required revisions, and priority levels

No	Component	Identified Issue	Required Revision	Priority
1	Methodology (ADDIE vs. R&D)	Inconsistency between the ADDIE framework and the 9-step R&D model.	Determine the primary model (e.g., ADDIE) and explain each stage explicitly and coherently.	Critical
2	Instructional Design & Ecolinguistic Integration	Lack of operational explanation on how ecolinguistic principles are applied.	Add a clear operational description such as environmental messages and cultural values.	Critical
3	Structure and Organization of the Manuscript	Insufficiently systematic structure: logical flow not clearly established.	Revise paragraph arrangement and improve transitions between key sections.	Critical
4	Abstract	Does not fully represent the research contribution and key findings.	Update the abstract with complete components including results and novelty.	Critical
5	References and Citations	Not aligned with journal style, not sequential, and some low-quality sources.	Use updated citation style and ensure recent relevant references.	Important
6	Figures and Tables	Low resolution and incomplete captions.	Improve image resolution and ensure captions in English.	Important
7	Novelty and Scientific Contribution	Contribution is seen as average by reviewers.	Add a clear novelty statement emphasizing unique aspects.	Important
8	Scaffolding and Classroom Implementation	Limited explanation of classroom use.	Add detailed explanation of instructional steps using the comic.	Moderate
9	Language and Narrative Clarity	Some sections are unclear or ambiguous.	Conduct academic proofreading as required.	Moderate

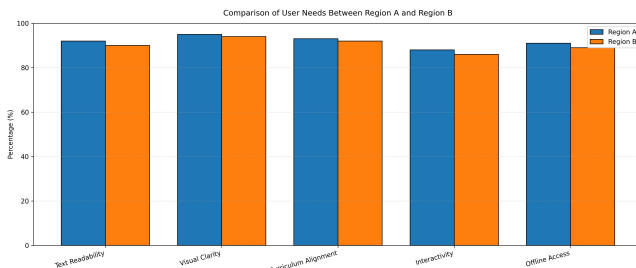


Fig. 5. Comparison of user needs between Region A and Region B.

The comparative analysis between Region A and Region B revealed highly consistent patterns of user needs across both locations. As illustrated in Fig. 5, respondents from the two

regions demonstrated similarly strong preferences toward key media features such as text readability, visual clarity, curriculum alignment, interactivity, and offline accessibility. Region A consistently showed slightly higher percentage values across all indicators, suggesting a marginally greater level of readiness and expectation toward digital learning media. However, the differences between the two regions remained small (ranging from 1–3%), indicating that user expectations for environmentally themed digital comics are broadly uniform across urban and rural contexts. These results confirm that the development of *El-Coming* aligns well with user needs in both regions, reinforcing the media's

relevance for wider implementation across diverse school environments.

V. DISCUSSION

A. Contribution and Novelty

Most of the recent research on digital comics for environmental education has focused on enhancing ecoliteracy through folktale based narratives using surveys to gauge students' knowledge without employing a language or discourse oriented analytical methodology. In contrast the current work presents a theoretical and methodological advancement by directly incorporating ecolinguistic concepts into both the design and analysis of digital comics. To achieve this integration Stibbe's ecological discourse framework is operationalized into narrative structures character dialogues and visual textual representations through clearly defined ecolinguistic indicators that guide discourse interpretation as well as media development. As a result the digital comic developed in this study serves not only as a tool for promoting ecoliteracy but also as a linguistically informed instructional medium that supports students' initial ecological understanding through discourse representing an innovation not addressed in previous environmental comic research [42].

Previous research on digital comics for environmental education has primarily focused on fostering environmental literacy through local wisdom narratives without employing an ecolinguistic or discourse based analytical paradigm. In such studies comics were developed to introduce environmental concepts and cultural values but were not examined through linguistic ecological theories. The present study applies ecolinguistic principles directly to the comic design by incorporating key concepts from Stibbe's ecological discourse framework into narrative structures character dialogues and visual textual representations. This study further develops explicit ecolinguistic indicators including ecological linkages beneficial ecological stories, linguistic choices and pro environmental ideologies which function as systematic guidelines for both media development and ecolinguistic discourse analysis. This approach represents a methodological and theoretical advancement beyond earlier comic based educational studies in Indonesia by positioning the digital comic not only as an instructional medium but also as a linguistically grounded tool that supports students' initial ecological awareness through language based narratives [43].

B. Interpretation of Findings

The results of this study show that the El-Coming digital comic meets the pedagogical, linguistic, and usability standards required for elementary-level environmental education. The expert validation results revealed unusually high ratings across all parameters, notably in digital comic design and language clarity, indicating that the media is visually cohesive, age-appropriate, and in line with ecological learning objectives. The flawless S-CVI/Ave score demonstrates that the evaluation tool used to certify El-Coming was extremely dependable and exact in capturing expert judgment.

The moderate learning gains observed in this study can be attributed to the way ecolinguistic narratives were integrated into the comic structure, allowing students to process

environmental concepts through culturally familiar language and visual storytelling rather than abstract exposition alone.

From an ecolinguistic perspective, the observed moderate learning gain reflected by the N-Gain score of 0.57 can be interpreted as the result of students' engagement with ecological metaphors and personification embedded in the comic narrative. By portraying nature as a living and relational entity, the comic encourages affective involvement and moral reflection, which are central to ecolinguistic theory. Unlike conventional expository learning media that primarily emphasize factual transmission, narrative-based ecological metaphors enable students to emotionally relate to environmental issues, thereby strengthening affective dimensions of environmental literacy within a short-term instructional context.

The comic reduces psychological distance and enhances engagement by presenting environmental challenges through familiar cultural tales and relational language, which facilitates students' short-term comprehension and emotional connection to environmental issues.

These findings suggest that El-Coming functions as a pedagogically appropriate learning medium that engages students with multimodal content, relatable characters, and ecologically grounded ideas within a short-term classroom context.

C. Comparison with Previous Studies

When compared to past research on digital comics and environmental education, this study strengthens existing evidence while making significant contributions. Previous research has demonstrated that digital comics can boost students' enthusiasm, comprehension, and ecoliteracy; however, most have concentrated on local wisdom, scientific principles, or civic issues without including an explicit ecolinguistic framework. Unlike prior studies that have focused solely on narrative or visual design, El-Coming adds linguistic ecology by incorporating environmental metaphors, character conversations, and culturally appropriate terms within the comic. This integrates the medium with not only environmental literacy aims, but also sociocultural and linguistic factors that were previously disregarded in comic-based interventions.

Studies on ADDIE-based digital media development have likewise yielded strong expert validation scores, often greater than 95%. El-Coming's validation results support this tendency, demonstrating that the ADDIE model remains a dependable platform for creating structured, high-quality educational media. Compared to previous research, this study broadens discussion by demonstrating how ecolinguistics might improve both narrative engagement and conceptual understanding in environmental learning.

When compared to prior studies on digital comics in environmental education, the moderate learning gain revealed in this study is comparable to results from treatments with short instructional durations. Studies demonstrating greater learning gains frequently included repeated exposure, longer implementation periods, or more extensive teacher scaffolding. In contrast, research that relies exclusively on visual storytelling with no clear linguistic or cultural framing usually shows smaller or inconsistent benefits. This study indicates that the incorporation of ecolinguistics and cultural

factors in El-Coming has a significant impact on learning effectiveness, even within a relatively brief classroom engagement.

D. Contribution, Novelty, and Theoretical Implications

This work makes several important contributions. First, El-Coming proposes a full integration of ecolinguistics with digital comic media, a method rarely used in environmental education research. By incorporating ecological values into language choices, character interactions, and storyline development, the media offers a linguistically grounded approach for supporting students' initial environmental understanding and awareness within a short-term instructional context.

Second, the work adds theoretical value by connecting multimedia learning theory to ecolinguistic concepts. The findings confirm Mayer's Cognitive Theory of Multimedia Learning, suggesting that combining text, visuals, and narrative improves memory retention and conceptual understanding. At the same time, ecolinguistic framing is consistent with sociocultural learning theory, demonstrating how environmental information incorporated in culturally recognizable language can boost relevance and emotional resonance.

Third, the incorporation of empirical measurements (CVI, N-Gain, and acceptance scores) provides a proven methodology for developing, assessing, and applying ecolinguistic digital media in primary education. This establishes a framework that future scholars can repeat or improve, resulting in a more transdisciplinary paradigm for sustainability-focused instructional design.

E. Limitations of the Study

Despite the excellent findings, the study has several drawbacks. First, the implementation was limited to a small number of schools and lasted just a short time, which may have missed long-term behavioral changes or varied contextual variables among larger populations. Second, some schools lacked proper technological infrastructure, which limited the use of the media's interactive aspects. Third, while experts and practitioners participated in the validation and feedback processes, broader stakeholder involvement, such as policymakers or curriculum designers, could improve the media's alignment with national educational frameworks.

These limitations do not undermine the validity of the findings but rather identify areas for improvement and further investigation.

F. Recommendations for Future Research

Future studies should examine expanding the implementation area to include schools from other locations, allowing for comparison studies across various sociocultural situations. Longitudinal research is also recommended to determine whether the behavioral and attitudinal effects of El-Coming endure over time. Technologically, media can be enhanced by including immersive features like Augmented Reality (AR), gamification aspects, or adaptive learning pathways that customize student experiences. Researchers may also investigate integrating El-Coming into Learning Management Systems (LMS) to increase accessibility and track student performance more effectively. Finally, future research should investigate the policy implications of

ecolinguistic media, specifically how these materials might help national green curriculum initiatives and sustainability instruction in elementary schools.

G. Limitations of the Study

Given the brief duration of the classroom implementation (40–60 min), the findings primarily reflect short-term instructional outcomes rather than sustained behavioral or worldview change. However, ecolinguistic theory suggests that repeated exposure to ecological narratives and metaphors may gradually influence learners' environmental attitudes and values over time. Future research should therefore employ longitudinal designs, repeated classroom interventions, and follow-up assessments to examine whether ecolinguistically framed digital comics can contribute to long-term affective and behavioral change.

VI. CONCLUSION

Given the short duration of the classroom implementation and the descriptive nature of the analysis, the findings should be interpreted as short-term instructional outcomes rather than evidence of long-term behavioral or worldview change.

This project created and verified El-Coming, a digital comic based on ecolinguistics that aims to increase environmental literacy among primary school kids. The medium displayed good feasibility and methodological soundness, as proven by expert validation scores of 95.5% and a Content Validity Index (S-CVI/Ave) of 1.00, showing excellent pedagogical alignment, linguistic precision, and ecological relevance. User evaluations validated the excellent practicality and attraction, with an overall approval percentage of 93.6% among teachers and pupils.

Classroom implementation showed meaningful learning improvements. Students' environmental literacy increased from an average of 62% (pre-test) to 84% (post-test), yielding a moderate N-Gain of 0.57, which reflects gains across cognitive, affective, psychomotor, social, and school-environment dimensions. Comparative analysis between urban (Region A) and rural (Region B) settings revealed only minimal differences (1–3%) across key indicators, supporting the applicability of El-Coming in diverse educational contexts.

Overall, the findings provide preliminary empirical evidence that ecolinguistically framed digital comics can support short-term improvements in environmental literacy and serve as a feasible instructional approach for introducing Education for Sustainable Development concepts in elementary schools.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

E. D. R. led the conceptualization of the study, designed the methodological framework, conducted the validation processes, and was responsible for the original draft preparation of the manuscript. She also coordinated the overall project administration and contributed substantially to the development of the ecological and instructional components of the El-Coming digital comic. U. H.

contributed to the development of the learning design, supported the formal analysis, assisted with data curation, and participated in the review and editing of the manuscript. She also played a key role in interpreting the pedagogical aspects of the findings. N. E. B. supervised the technical components of the project, including software-related considerations, resources management, and visualization. He also contributed to the investigation, refinement of multimedia elements, and the final review of the manuscript. All authors reviewed and approved the final version of the manuscript.

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