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From passive consumption to reflexive engagement in environmental education: Cultivating Generative Environmental Media Literacy (GEN-EML) through connectivist digital pedagogy

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ABSTRACT

As environmental crises increasingly unfold within digitally mediated environments, higher education must prepare communication students to critically interrogate how environmental knowledge is constructed, framed, and contested across media systems. This study conceptualizes Environmental Media Literacy (EML) as a multidimensional competence integrating epistemic evaluation, ideological critique, affective–ethical reflexivity, and civic–communicative agency. Using a convergent mixed-methods quasi-experimental design ($n = 60$), we examined the short-term impact of a four-week documentary-based digital pedagogy intervention on undergraduate communication students within the connectivist framework. Quantitative findings indicate pre–post gains across three outcome measures, though effect sizes are interpreted cautiously given the short intervention period. Qualitative analyses of focus groups and written critiques reveal increased epistemic vigilance, heightened framing awareness, and more reflexive engagement with environmental narratives. Findings show that integrating documentary-based digital learning media through the connectivist framework facilitates GEN-EML as a theoretically grounded, replicable framework for embedding critical environmental media literacy within communication curricula.

KEYWORDS

environmental education; critical media literacy; digital pedagogy; connectivism; sustainability; documentary-based learning

Introduction

Climate change represents one of the most urgent and complex challenges of the twenty first century, with far-reaching implications for ecological systems, human livelihoods, and global governance. The pervasive environmental crisis, encompassing issues like climate change, is too complex to be resolved using the methods of a single scientific field, thus requiring interactive and multi-disciplinary strategies. Although public knowledge concerning environmental issues is expanding significantly, collective action responding to scientific warnings is still exceedingly sluggish, revealing a profound disparity between public awareness and necessary response (Portus et al., 2024). As public and sectoral awareness and policy debates increasingly unfold within mediated spaces, the role of media and communication in shaping perceptions of environmental issues has become both powerful and contested. Documentaries, news reports, and social media campaigns can illuminate scientific evidence, amplify calls for environmental justice, and mobilize collective action. At the same time, these mediated narratives are frequently shaped by ideological frames, selective use of evidence, and strategic messaging that may obscure competing perspectives or structural causes of ecological crises (Bybee, 2020; López, 2014; Rojas-Estrada et al., 2024; Rosenthal, 2020; Yıldırım et al.).

Existing theoretical traditions have each made significant contributions to understanding the relationship between education, media, and environmental agency; yet none has proven sufficient to address

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the specific competency demands facing today's communication students. Environmental literacy frameworks, emerging from Roth's (1992) foundational taxonomy and later elaborated through ecopedagogy and socio-critical traditions, foreground ecological knowledge, values, and action competence as central outcomes. However, they have historically undertheorized the role of mediated communication in constructing environmental meaning, treating media largely as a conduit for information delivery rather than as a constitutive force in shaping what "counts" as environmental knowledge. Similarly, action competence models, such as Jensen and Schnack (1997) influential formulation, emphasize democratic participation and transformative agency but remain anchored in formal educational settings and largely predate the digital and algorithmic turn in information ecology. Critical media literacy, advancing the work of Kellner and Share (2005), and others, offers powerful tools for interrogating power, ideology, and representation in mediated texts. Yet its environmental application has remained peripheral, and it has not systematically engaged with the epistemic challenges specific to environmental science communication, including contested evidence, manufactured uncertainty, and the affective dimensions of ecological grief and moral responsibility. What remains relatively underexplored across these traditions is a framework that treats the mediated construction of environmental knowledge as a central rather than supplementary concern of literacy education, and that orients this toward the digital environments in which contemporary communication practice increasingly takes place.

The deficiency of these traditions, however, is not adequately captured by observing that each *underemphasizes* mediated environmental knowledge, for such a diagnosis invites the obvious remedy of combination. The more fundamental problem is that, when confronted with a single mediated artifact, the traditions generate divergent and even contradictory verdicts that the learner has no principled means of reconciling. Consider a viral environmental documentary that is simultaneously evidentially flawed, structurally pointed, affectively engineered, and algorithmically amplified. An environmental-literacy reading is disposed to reject the text—thereby discarding its valid structural critique along with its errors. A critical-media-literacy reading risks endorsing as liberatory a text that is, in part, misleading. An action-competence reading cannot determine whether the proposed action is warranted by the evidence. Each tradition resolves one axis of the artifact and, in doing so, actively suppresses the others. This is precisely why the deficiency cannot be remedied by combination. Placing these frameworks side by side does not yield a fuller account; it yields competing adjudications—"false, therefore reject" versus "subversive, therefore embrace"—with no shared logic for weighing the evidentiary, ideological, affective, and circulatory dimensions against one another. What is missing is not a further tradition to add to the stack but an integrating axis that renders these readings commensurable. Digital mediation is that axis.

For communication students as future media producers and interpreters, these dynamics present both an opportunity and a challenge. On the one hand, they must be equipped to critically evaluate environmental media and communication content in order to discern credible evidence, identify framing strategies, and detect omissions or distortions. On the other hand, they carry the professional responsibility of crafting environmental narratives that are accurate, balanced, and socially responsible. Yet existing evidence suggests that students in communication-related disciplines often approach environmental content with limited critical depth, accepting narratives at face value and engaging minimally with their epistemic and ideological underpinnings. This gap in critical engagement is particularly concerning in the context of sustainability communication, where misinformation, oversimplification, and uncritical replication of dominant narratives can undermine public understanding and hinder effective environmental action once these students advance into sectoral placement (Afrilyasanti et al., 2024; Mendoza et al., 2020).

The distinctive epistemological conditions of contemporary digital environments place particular demands on existing frameworks; demands that were not fully anticipated when those frameworks were developed at first place. Environmental claims today circulate not through stable, institutionally vetted channels but through algorithmically curated feeds, platform-specific documentary ecosystems, and networked activist communities that simultaneously empower and distort environmental publics. Environmental literacy frameworks were largely designed for pre-digital contexts; critical media literacy has engaged with algorithmic amplification at the margins of its theoretical agenda; and action competence models have yet to fully reckon with the ways that civic agency is mediated and constrained by

digital platforms. Together, these limitations reveal a meaningful gap in the existing literature, not a total absence of relevant thinking, but an absence of integration toward digitally mediated environmental communication. Addressing this gap does not require setting aside the contributions of established traditions. Rather, it requires drawing them into a more purposeful synthesis: one that reconceptualises the relationship between epistemic evaluation, structural critique, affective engagement, and communicative action as mutually reinforcing capacities, shaped by and exercised within digital media ecologies. Existing frameworks offer indispensable resources for this work; what has been necessitated lately is a coherent framework that brings these dimensions together with digital mediation as its organizing concern. This is the integrative theoretical space into which the present study intervenes and discusses thoroughly, and it is the contribution that GEN-EML is designed to make, with its strengths and constraints.

Additionally, while the fields of environmental and media literacy have each developed substantial theoretical and pedagogical frameworks, their integration into sectoral skills-sets for undergraduate students remains underexplored. Environmental education has evolved to incorporate experiential learning, ecopedagogy, and socio-political awareness, while media literacy scholarship, particularly in its critical form, emphasizes the interrogation of power, ideology, and representation in mediated texts. However, empirical interventions that explicitly combine these domains to address environmental media literacy as a future competency are scarce. Moreover, few studies have operationalized environmental media literacy as a measurable construct, and even fewer have examined the impact of targeted digital learning interventions such as documentary-based modules on communication students' cognitive, affective, and behavioral competencies in this area. This gap points to an urgent need for research that both conceptualizes and empirically evaluates strategies for fostering environmental media literacy in higher education contexts and further (Campbell et al., 2021; Lo Iacono et al., 2024).

In an era of information abundance and accelerating ecological change, students must navigate distributed networks of shifting data rather than simply acquire static knowledge. This study situates Environmental Media Literacy (EML) within a Connectivist framework, wherein learning involves connecting specialized nodes of information. As environmental crises are increasingly mediated through "communicative infrastructures" and "algorithmic amplification," synthesizing disparate environmental claims becomes a foundational competency. Viewing EML as a network-based skill illuminates how students move beyond recall toward reflexive engagement with polarized digital ecosystems shaping contemporary sustainability discourse. This connectivist orientation is not merely additive but structurally reshapes each of the four literacy dimensions: epistemic evaluation becomes a networked practice of triangulating contested knowledge nodes; ideological critique extends to the algorithms and platform architectures that curate environmental visibility; affective–ethical reflexivity is exercised in relation to digitally mediated experiences of ecological crisis; and civic–communicative agency is enacted through the very media production and circulation practices that define communication professionals' roles.

Recent scholarship reflects a growing call for convergence. Eco-critical media curricula merge environmental ethics with media analysis (Campbell et al., 2021), while sustainability communication research stresses integrating analytical and production competencies (Cheung & Chau, 2017; Cruz et al., 2025). Digital pedagogies, including documentary-based learning and immersive simulations, show promise for engagement and knowledge acquisition (Hetherington et al., 2026; Nurtanto et al., 2021; Ruan, 2022). Yet empirical research systematically operationalizing an integrated EML construct remains limited, as existing tools assess environmental attitudes, health literacy, or media literacy independently (Eristi & Erdem, 2017; Irvin et al., 2019; Rohlman et al., 2022). The fragmentation of these assessment tools mirrors the fragmentation of the underlying theoretical traditions, each capturing a partial view of a competency that is, in practice, holistic and relational.

In response, this study advances EML as a distinct, multidimensional competence that does not simply consolidate prior traditions but reconceptualizes their relationship around the specific site of digitally mediated environmental communication. The framework integrates four mutually reinforcing dimensions: (1) "epistemic evaluation of environmental claims", that's, attending to the evidentiary standards, credibility hierarchies, and uncertainty constructions unique to environmental science communication; (2) "ideological and structural critique of mediated environmental narratives" that means extending

critical media literacy's analytical tools to address platform economics, corporate environmental messaging, and the politics of climate representation; (3) "affective–ethical reflexivity" recognizing that engagement with environmental media is inherently emotionally charged and morally implicating, requiring pedagogical attention to the subjective dimensions of ecological literacy; and (4) "civic–communicative agency" that foregrounds communication students' dual positioning as both critical consumers and responsible producers of environmental media content. These four dimensions are collectively formalized as Generative Environmental Media Literacy (GEN-EML). The term "generative" signals the framework's departure from transmission-based or purely analytical models: GEN-EML is oriented toward the productive, transformative capacities of literacy; toward students who do not merely decode environmental media but actively participate in shaping environmental public discourse. This generative orientation distinguishes GEN-EML from critical media literacy, which has historically emphasized deconstruction over production, and from environmental literacy, which has not foregrounded the communicative and media-specific dimensions of ecological agency. It is also analytically distinct from action competence models, which conceptualize civic participation in broadly democratic terms rather than in relation to the specific affordances and constraints of digital media environments.

This study addresses the above-identified gaps by designing and evaluating a documentary-based digital learning intervention aimed at enhancing environmental media literacy among undergraduate communication students as a required career skill (Akakpo et al., 2024; Erguvan, 2024). Environmental education is fundamentally centered on promoting action for the environment, requiring the cultivation of connections to nature, the development of values, and a comprehensive understanding of environmental complexities (Portus et al., 2024). Interventions should integrate education and persuasion, aiming to maximize effectiveness in fostering behavior change, surpassing strategies focused solely on attitude adjustment or knowledge acquisition (Cruz et al., 2025). By integrating high-quality environmental documentaries with interactive learning activities and critical discussion prompts, the intervention sought to cultivate students' ability to critically interpret, evaluate, and reflect upon environmental media narratives. The significance of this research lies in its holistic approach, targeting not only cognitive gains, such as improved critical analysis and knowledge retention, but also affective and behavioral outcomes, including shifts in environmental attitudes and intentions to engage in sustainable practices.

To examine its pedagogical viability through a connectivist lens, the study implemented a four-week documentary-based digital learning intervention in an undergraduate communication course, combining screenings, source evaluation, framing analysis, reflexive journaling, and media production tasks. A convergent mixed-methods quasi-experimental design assessed changes in EML, environmental attitudes, and sustainability knowledge, while qualitative analysis explored shifts in students' interpretive and ideological positioning. The study was guided by three interrelated research questions:

- To what extent do documentary-based digital learning modules influence communication students' critical environmental media literacy skills across interpretive and evaluative dimensions?
- How do interactive sustainability-themed media platforms influence communication students' environmental attitudes, knowledge retention, and behavioral intentions?
- In what ways do critical media literacy training programs affect students' epistemic evaluation and ideological critique of environmental journalism and documentary narratives?

This research makes several contributions to the literature. Theoretically, it advances the conceptualization of environmental media literacy as a relatively distinct, multidimensional construct; one that seeks to move beyond the synthesis of existing frameworks to articulate a new analytical logic adequate to the conditions of digital environmental communication. By centering the specific epistemological and communicative challenges posed by algorithmically mediated environmental discourse, GEN-EML contends to offer theoretical purchase that critical media literacy, environmental literacy, and action competence models are challenged to provide independently or in combination. Pedagogically, it demonstrates the efficacy of a connectivist learning model that combines documentary film with interactive digital activities, offering a replicable framework for integrating sustainability education into communication

curricula to prepare students for future careers. Methodologically, it employs a mixed-methods design, combining quantitative measures of literacy, attitudes, and knowledge retention with qualitative analysis of focus group discussions and written critiques, to provide a nuanced, triangulated account of how critical environmental media literacy can be effectively fostered in higher education contexts.

Literature review

Foundations of environmental media literacy

Media and communication literacy is a broad field shaped by rapidly changing media environments. Environmental literacy is increasingly multi-dimensional, extending beyond factual knowledge to include cognitive, emotional, and behavioral dimensions (Jia & Wang, 2024). As learning is now deeply mediated, digital competence centers on the ability to access, analyze, evaluate, and create media across formats (Mulà & Tilbury, 2025) that are competencies often framed as prerequisites for participation in information societies (Scheibe & Rogow, 2012), with particular emphasis on interpretive skills for young people (Livingstone, 2004) and empirically measurable outcomes across age groups (Arke & Primack, 2009).

Environmental communication education (ECE) has likewise shifted from transmitting ecological facts toward reflective and socially engaged learning. Effective ECE promotes participatory learning and political engagement (Levy & Zint, 2013), critical thinking in complex cultural settings (Slimani et al., 2021), and place-based reconnection with local contexts (Garzón et al., 2020). Ecopedagogy combines ecological literacy with critical pedagogy to challenge dominant narratives and structural drivers of harm (Payne, 2015), while also valuing Indigenous and local knowledge (Nascimento, 2019) and aligning with Education for Sustainable Development goals (Pauw et al., 2015).

Digital media literacy emphasizes skills for identifying misinformation and engaging ethically in platform-driven environments (Nanda & Budimansyah, 2020), blending information literacy, technical fluency, and digital citizenship (Yang, 2023) to support democratic co-creation in participatory cultures (Mihailidis & Thevenin, 2013). Critical media literacy moves further by interrogating ideology and power, linking media analysis to social justice (Kellner & Share, 2005, 2007), exposing systemic inequities (Funk et al., 2016), and building civic agency (Garcia et al., 2013).

Each of these traditions contributes essential elements as epistemic evaluation, ideological critique, affective engagement, and civic participation, but they remain disciplinarily siloed. None was designed to address the specific condition in which learners encounter environmental crises *primarily* through algorithmically curated, ideologically contested, and affectively charged digital media. This gap motivates the integrated model proposed here.

Integration of environmental education and media literacy

The convergence of media literacy and environmental education has become increasingly urgent as ecological crises intensify and media strongly shapes public understanding. Environmental education aims to promote action by fostering connection with nature, cultivating values, and building holistic understanding (Portus et al., 2024). Although the two fields emerged separately, recent scholarship supports integrating them into environmental media literacy: the capacity to critically interpret, evaluate, and respond to mediated environmental information. This integration is vital because environmental messages are rarely neutral, often reflecting ideological frameworks and selective evidence (Cruz et al., 2025), and because media literacy supports the socially responsible participation essential for environmental engagement (Mihailidis & Thevenin, 2013). Embedding media literacy in curricula helps students navigate contradictory environmental narratives while strengthening eco-consciousness and critical analysis (Cheung & Chau, 2017).

Promising pedagogical models already bridge the fields in partial ways. Experiential approaches combine local environmental action with reflection on how knowledge is framed and circulated through media (Syarah et al., 2020). Ecopedagogy encourages learners to question both environmental harm and

its mediated representation, while eco-critical media curricula merge ecological ethics with media critique to examine how responsibility is constructed in discourse (Campbell et al., 2021). Interactive simulations support contextual reasoning (Matuk et al., 2022), and inquiry-based media projects on local issues increase critical awareness and civic participation (Beikutova et al., 2024).

Yet these efforts remain partial integrations. Critical media literacy foregrounds ideological critique but undertheorizes environmental affect and stewardship; environmental education foregrounds values and behavior change (Demirel, 2023) but lacks systematic tools for assessing source credibility or platform logic. Climate misinformation makes this gap consequential: environmental education alone does not equip learners to detect bias or resist manipulation in digital spaces (Bulger & Davison, 2018), while media literacy alone does not cultivate the ethical commitment to sustainability that environmental action requires. The model proposed in this article addresses this mutual incompleteness, not by combining two traditions additively, but by reconceptualizing the learning task as one that is simultaneously epistemic, ideological, affective, and civic within specifically digital-ecological contexts.

Connectivist theory, digital learning tools and pedagogical outcomes

The shift toward digital and documentary-based pedagogies necessitates moving from traditional constructivism to Connectivism, a learning theory that accounts for the platform-mediated information flows inherent in environmental communication education (Yang, 2023). Connectivism argues that "the pipe is more important than the content", that's, the ability to evaluate and traverse information pathways is more critical than memorizing isolated facts. Within the GEN-EML framework, Dimension 1 (Epistemic Evaluation) and Dimension 4 (Civic–Communicative Agency) directly align with connectivist principles: they require learners to distinguish credible scientific "nodes" from "ideological reframing" (Arenas et al., 2026) while actively contributing ethically grounded narratives back into the network, bridging individual cognition and broader socio-ecological systems where knowledge is actively constructed and shared.

As future media producers, communication students can shape how environmental issues are represented and understood; the challenge is both consuming and reframing sustainability narratives for public discourse. Persuasive communication is more effective when it targets central concepts in audiences' cognitive structures (Cruz et al., 2025). News analysis trains students to examine topic selection, framing, and the ways journalistic routines sensationalize or marginalize environmental issues (Luedecke & Boykoff, 2017). Narrative forms such as climate fiction help challenge entrenched norms and imagine alternative futures (Nordh et al., 2026), while visual and entertainment media highlight how imagery, storytelling, and emotion shape engagement with sustainability (Hansen, 2017). These pedagogical affordances inform each dimension of the GEN-EML model developed below.

Theoretical and methodological gaps in environmental media literacy

Despite growing interest in the overlap of media and communication literacy and environmental communication education, environmental media literacy (EML) remains inconsistently defined and weakly theorized. Environmental literacy is now widely treated as a multidimensional construct that includes cognitive, affective, and behavioral components beyond factual knowledge (Jia & Wang, 2024). Recent work nonetheless signals a move toward consolidating EML as a distinct framework: López (2019) frames EML as a hybrid literacy focused on the reciprocal relationship between media systems and ecological crises and the critical deconstruction of environmental narratives. This is reinforced by the view that environmental communication is rarely neutral, often reflecting ideological framings and selective evidence that audiences must interrogate and by arguments linking environmental consciousness to media engagement in educational settings (Cruz et al., 2025).

This shift is also visible in pedagogies that merge critical literacy with ecological awareness. Campbell et al. (2021) propose an "embodied" literacy positioning learners as reflexive actors within media production and ecological systems, while Vinoharan and Vinoharan (2024) advocate curricula that integrate environmental responsibility with media engagement to cultivate sustainable citizenship. However, key

dimensions remain underdeveloped; particularly local knowledge, cultural specificity, and community-based media practices. Addressing disparities in underserved communities may require adaptable, interdisciplinary, and culturally responsive curricula; otherwise EML remains aspirational rather than operational (Bada et al., 2024).

A major barrier is the lack of dedicated, validated EML measurement tools. Existing instruments assess adjacent domains, such as environmental health literacy or general media literacy, without capturing integrated competencies for analyzing and producing environmental media. Measures such as the Water Environmental Literacy Level Scale (Irvin et al., 2019), the Short Assessment of Environmental Health Literacy (Rohlman et al., 2022), and the Environmental Health Literacy Scale (Lichtveld et al., 2019) focus on environmental health knowledge, attitudes, and behaviors but offer limited media-specific coverage. Conversely, the Media Literacy Skills Scale assesses access, analysis, and communication skills yet lacks ecological content (Eristi & Erdem, 2017). Other scales offer partial templates but limited transferability, including dietary media messaging measures (Chen et al., 2017) and a sustainability-oriented survey narrowly tied to green building and architectural literacy (Cole & Hamilton, 2020). Together, these gaps indicate the need for a psychometrically validated instrument designed specifically for EML.

Another related gap is the incomplete alignment of digital pedagogy with sustainability communication. Calls for coherent integration link active digital learning to sustainability competencies (Lozano et al., 2023), and examples show Sustainable Development Goals can be embedded through digital platforms in language curricula (Ruiz et al., 2024). Interdisciplinary and community-based digital pedagogies are also supported (Batri et al., 2022; Mukoni, 2015), yet institutional approaches are often fragmented without cohesive frameworks (Chen, 2017). Evaluation is frequently weak and short-term, with limited attention to lasting impact (Lozano et al., 2017), and without institutional reform, digital sustainability education may remain peripheral (Sammalisto et al., 2016).

Methodological limitations further constrain the field, including small samples (Witek & Grettano, 2014), short-term interventions that fail to track durable attitudinal or behavioral change (Tsekhmister, 2022), limited demographic diversity (Oden & Porter, 2023), and weak evaluation frameworks that integrate cognitive, emotional, and behavioral multiliteracy outcomes (Dewi et al., 2023). In response, the present study adopts a mixed-methods design to examine EML development among communication students. It follows multidimensional evaluation of knowledge, affective engagement, and behavioral intent (Carpenter & Munshower, 2019), incorporates participatory action research with instructors and community stakeholders, and draws on measures of digital pedagogy competence to assess digital engagement alongside sustainability literacy (Rawat et al., 2023).

Theoretical and conceptual framework: Toward a generative model of environmental media literacy (GEN-EML)

The reviewed scholarship converges on several key insights. Environmental crises are socio-political and structurally embedded (Slimani et al., 2021). Environmental communication shapes public perception and policy discourse (López, 2014; Cruz et al., 2025). Digital ecosystems amplify ideological framing and misinformation (Arenas et al., 2026; Treen et al., 2020; Yang, 2023). Critical media literacy offers tools for interrogating representation and power (Kellner & Share, 2005, 2007). Documentary-based and digital pedagogies can enhance engagement when critically scaffolded (Campbell et al., 2021; Hetherington et al., 2026).

Through this lens, the present study moves beyond a descriptive analysis of media framing to engage with the structural ideologies that drive environmental discourse. As Arenas et al. (2026) argue, environmental misinformation is not merely an educational failure but a strategic instrument used to protect entrenched interests and maintain ideological control. This manufactured doubt has a documented empirical history: Supran and Oreskes (2021), in a computational frame analysis of more than two hundred ExxonMobil documents, show that fossil-fuel communications systematically deployed rhetoric of "risk" and consumer "demand" to downplay the reality of anthropogenic warming and to shift responsibility away from producers and onto individual consumers. Such narratives further entrench dominant paradigms by marginalizing alternative epistemologies; as Roy (2026) argues, a decolonial environmental education requires an ontological shift that rejects the commodification of nature. The persistence of

these frames, despite escalating ecological breakdown, suggests a metacrisis in which familiar narratives of progress obscure reality through psychological disavowal (Li Mandri, 2026). Confronting these structural roots necessitates a pedagogy that accounts for the haunting pasts-presents-futures of settler colonialism and the material consequences of natural-cultural hegemony (Jukes & Riley, 2024), and that adopts a posthumanist lens to decenter human exceptionalism, replacing extractionist mentalities with a self-understanding grounded in relationality with the more-than-human world (Jordan & Jónsson, 2025).

Taken together, these strands reveal the need for an integrative framework that conceptualizes environmental literacy as inseparable from media critique and communicative agency—encompassing epistemic evaluation, ideological analysis, reflexive ethics, and participatory production. The present study responds to this need by advancing Environmental Media Literacy (EML) as a multidimensional competence and empirically examining its short-term development within a structured documentary-based digital intervention.

The proposed framework: From convergence to conceptual integration

Environmental literacy, critical media literacy, and digital literacy have developed along parallel trajectories. Yet in digitally mediated ecological crises, these domains intersect. Environmental knowledge is encountered through communicative infrastructures shaped by political economy, cultural ideology, and algorithmic amplification.

Generative Environmental Media Literacy (GEN-EML) is proposed as a generative framework that integrates these traditions while aiming to advance beyond their additive convergence. GEN-EML is defined as multidimensional competence enabling learners to critically evaluate environmental knowledge claims, interrogate ideological and structural power relations embedded in environmental communication, reflect on their ethical positioning, and act as responsible communicative agents within socio-ecological systems. This model draws from:

- Constructivist learning theory (knowledge as actively constructed),
- Critical pedagogy (power and ideology),
- Political ecology (structural drivers of ecological crisis),
- Connectivist digital literacy scholarship (platform-mediated information flows).

The decisive question, however, is not whether each dimension can be traced to a prior source but whether anything emerges from their combination that the sources cannot deliver independently or additively. Table 1 demonstrates that something does. When a single mediated controversy is read through each tradition in turn, the traditions do not produce complementary partial accounts that a researcher could simply sum; they produce incompatible adjudications.

The worked case is the documentary Seaspiracy (2021), chosen because it is generically identical to the media used in the present intervention and because its evidentiary genealogy is fully documented. The film's alarming "oceans empty by 2048" claim traces to a press-release framing of Worm et al. (2006), whose projection of global fisheries collapse sparked formal scientific controversy and multiple published rebuttals—one of which, recomputing the same data, obtained a collapse date of 2114 rather than 2048, demonstrating that the projection was highly sensitive to the statistical model chosen (Wilberg & Miller, 2007). A subsequent citation analysis showed that the original coauthors themselves almost never repeated the 2048 figure, even as it propagated through lower-impact and non-specialist outlets (Branch et al., 2013). The documentary revived this contested framing years later; interviewed marine scientists reported that their statements were taken out of context, and several criticized the film for exaggeration and for asserting links unsupported by evidence. Yet the film also surfaced genuine concerns—including a pointed critique of industry-captured "sustainable" certification—and was algorithmically propelled into Netflix's most-watched ranks. The same artifact is therefore, at once, evidentially shaky, structurally insightful, affectively engineered, and virally amplified.

As Table 1 shows, environmental literacy's accuracy criterion rejects the text; critical media literacy's ideology criterion embraces it; action competence's participation criterion mobilizes around it. A learner

Table 1. GEN-EML: one mediated environmental controversy (the viral documentary Seaspiracy, 2021).

Reading lens	Guiding question	Verdict on the artifact	What it makes visible	What it cannot resolve
Environmental literacy (Roth, 1992)	Is the science accurate?	Largely reject: the "2048 collapse" claim is a contested press-release framing later recomputed to 2114 (Branch et al., 2013; Wilberg & Miller, 2007; Worm et al., 2006)	Evidentiary unreliability; misuse of dated data	Why a flawed text still circulates and persuades; that its structural critique is partly valid; the medium's own logic
Critical media literacy (Kellner & Share, 2005)	Whose power and ideology are served?	Largely embrace: the film exposes industry-captured certification	Ideological function; representation; counter-hegemonic potential	Whether the evidence is sound—risks endorsing a partly-misleading text as liberatory
Action competence (Jensen & Schnack, 1997)	What should we do?	Convert to action: e.g., a behavioral-change campaign	Civic agency; democratic participation	Whether the action is evidence-warranted; that the relevant "action" here is media circulation, itself platform-mediated
Connectivism	How is knowledge distributed across the network?	Map the nodes circulating the claim	The networked, distributed character of the knowledge	How to weight nodes by credibility; that the platform is an interested actor, not a neutral conduit
Their combination	—	Incoherent: "reject" vs. "embrace" vs. "mobilise"	Four partial readings	No shared logic to reconcile contradictory verdicts
GEN-EML (this study)	How do evidentiary status, ideological function, affective design, and circulation co-constitute this artifact—and what stance should I take as its potential re-circulator?	Adjudicate and re-produce: treat the film as evidentially flawed and structurally insightful and affectively engineered and algorithmically amplified, then craft a more accurate counter-narrative	The entanglement of all four axes around digital mediation	(Resolves the contradiction the others cannot); its surplus is the integrating axis plus the generative, producer-facing demand

No row above is wrong; each is partial, and—decisively—their conjunction is contradictory rather than cumulative. GEN-EML's distinctiveness lies in the integrating axis (digital mediation) that makes the four readings commensurable, and in the generative requirement that the learner reenter the same circulation as a producer.

equipped with all three, but with no principle for adjudicating among them, is left not with a richer analysis but with a contradiction. GEN-EML supplies the missing principle by relocating all four readings onto a single axis—the digital mediation through which the artifact's evidentiary, ideological, affective, and circulatory properties are jointly produced—and by closing the analysis not in judgment but in production. This is the sense in which GEN-EML is re-specifying rather than synthetic: it does not federate the traditions; it changes the unit of analysis from the literacy to the mediated artifact, and the end-point from critique to generative agency.

GEN-EML is accordingly defined as a multidimensional competence enabling learners to critically evaluate environmental knowledge claims, interrogate the ideological and structural power relations embedded in environmental communication, reflect on their own ethical positioning, and act as responsible communicative agents within socio-ecological systems. The model draws from constructivist learning theory (knowledge as actively constructed), critical pedagogy (power and ideology), political ecology

(structural drivers of ecological crisis), and connectivist digital-literacy scholarship (platform-mediated information flows).

Dimension 1: Epistemic evaluation. This dimension encompasses the analytical capacity to evaluate scientific credibility, detect misinformation, identify framing devices, and interpret uncertainty communication. In an era of contested climate science and strategic doubt, epistemic vigilance is foundational. The Seaspiracy case illustrates that this is not a matter of simple fact-checking: the disputed claim was not a fabrication but a real peer-reviewed projection whose press-release framing outran its evidentiary base (Branch et al., 2013; Worm et al., 2006). Epistemic evaluation, however, is insufficient without structural awareness; fact-checking alone cannot dismantle hegemonic narrative systems.

Dimension 2: Ideological and structural critique. Drawing on political ecology and eco-Marxist perspectives, this dimension emphasizes that environmental discourse is embedded in global systems of capital accumulation, colonial extraction, and geopolitical asymmetry. Narratives emphasizing individual lifestyle change may obscure fossil-fuel dependency or structural inequality—a dynamic empirically demonstrated in Supran and Oreskes (2021) analysis of how industry communications individualized responsibility through "demand"-side rhetoric. EML therefore requires learners to interrogate whose interests are advanced by particular framings and how discursive strategies normalize or contest existing power structures.

Dimension 3: Affective–ethical reflexivity. Environmental media often mobilizes fear, guilt, hope, or nostalgia. Emotional engagement can motivate action but may also produce paralysis or cynicism. EML includes critical awareness of affective appeals and reflection on one's positionality within ecological systems.

Dimension 4: Civic–communicative agency. Unlike purely analytical models, EML culminates in production. Communication students must learn to create ethically grounded, evidence-based environmental narratives, reentering the circulation they have learned to analyze. This dimension aligns with sustainability competencies that emphasize participation and responsibility (Cheung & Chau, 2017).

Together, as Figures 1–2 display, these dimensions form an integrated model in which evaluation, critique, reflexivity, and agency reinforce one another around the organizing concern of digital mediation.

Methodology

Research design

This study employs a convergent mixed methods design, combining a quasi-experimental quantitative approach with qualitative thematic analysis. This methodological framework was selected to address the multifaceted nature of the research questions, which require both measurable indicators of learning outcomes and interpretive insights into epistemic and ideological shifts in students' environmental media critique. The quantitative strand focuses on assessing the effects of documentary-based digital modules and interactive media platforms on students' critical environmental media literacy, environmental attitudes, and knowledge retention. In parallel, the qualitative strand explores how these interventions reshape students' interpretive and ideological perspectives on environmental journalism and documentary narratives.

The mixed methods approach aligns with the study's broader aim to bridge cognitive, affective, and behavioral domains of environmental education through media literacy training. By integrating numeric data with contextualized qualitative narratives, this design enables a more comprehensive understanding of how students not only learn from, but also *relearn through*, media engagement. The use of a quasi-experimental design in the quantitative phase allows for comparison between intervention and control

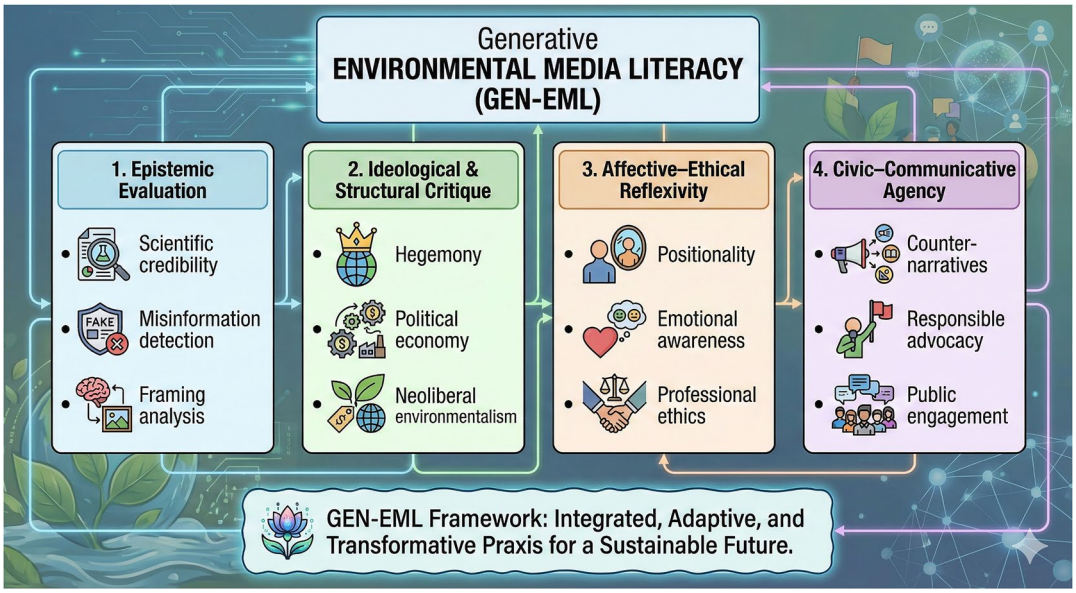


Figure 1. GEN-EML Theoretical/Conceptual Framework (Enlivened).

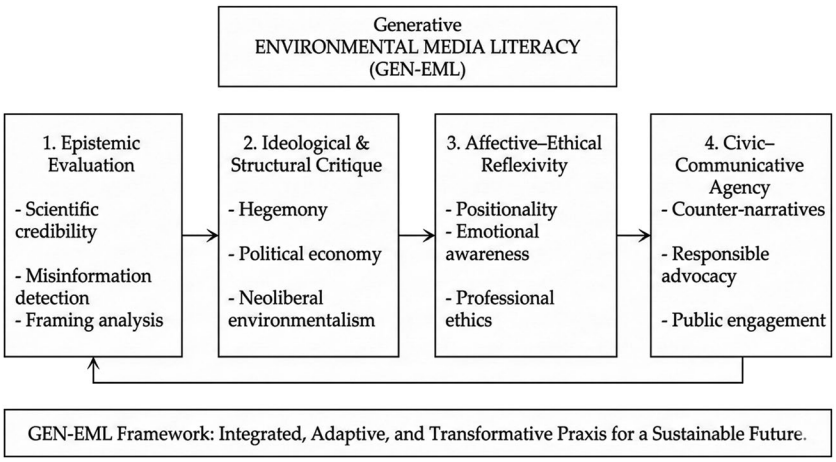


Figure 2. GEN-EML Theoretical/Conceptual Framework (Plain).

groups, while the qualitative phase provides a reflexive space to uncover deeper epistemological transformations that may not be captured by standardized instruments.

Although the intervention unfolded across four weeks, the design is best characterized as a short-term quasi-experimental intervention, rather than longitudinal. No delayed post-test was administered; therefore, findings might not reflect durable transformation and in-depth learning outcomes. The mixed-methods structure allowed triangulation between measurable shifts and discursive evidence of interpretive change, strengthening inferential depth.

Participants and sampling

The study will be conducted with undergraduate communication students ($n = 60$) enrolled in a media studies course at a mid-sized foundation university. Participants will be selected using a purposive sampling strategy, with an emphasis on students who have had preliminary exposure to media literacy concepts as part of their core curriculum. This selection criterion ensures that participants possess a

baseline understanding of media analysis, thereby enhancing the reliability of post-intervention assessments.

Students will be randomly assigned into two groups: an experimental group ($n = 30$) and a control group ($n = 30$). Stratified randomization will be used to maintain demographic balance in terms of gender and academic standing. The experimental group will participate in a four-week digital learning module integrating environmental documentaries and interactive sustainability-themed platforms. The control group will continue with traditional instruction based on conventional media literacy content without specific environmental focus.

This sample size is considered sufficient for detecting moderate effect sizes in ANCOVA analyses, assuming an alpha of .05 and power of .80. The qualitative phase will include a subsample of 10 students from the experimental group, selected based on diversity in their initial responses and performance, to participate in focus group interviews and document analysis tasks. This subsample will provide rich narrative data on students' interpretive shifts and ideological positioning in relation to environmental media content.

Instruments and measures

To comprehensively assess the impact of the intervention on communication students' environmental media literacy and sustainability-related dispositions, the study employs both standardized and researcher-developed instruments aligned with the three research questions. The instruments are organized according to the quantitative and qualitative strands of the mixed methods design.

Quantitative instruments. It should be noted that the instruments CEMLS, EAI, and BIM operationalize selected aspects of the GEN-EML framework's dimensions rather than capturing the construct in its full theoretical scope; dimensions such as the affective and communicative resist straightforward quantitative capture, and the instruments employed here are best understood as complementary proxies rather than comprehensive operationalizations of the framework.

Critical environmental media literacy scale (CEMLS). Adapted from the Media Literacy Skills Scale by Eristi and Erdem (2017), the CEMLS measures students' ability to access, interpret, evaluate, and critique environmental media content, particularly documentaries and journalistic texts. The adapted scale incorporates constructs from Kellner and Share's (2007) Critical Media Literacy framework, including ideological critique, source credibility evaluation, and narrative framing analysis. The scale consists of 24 Likert-type items rated on a 5-point scale, with subscales for interpretive competence and evaluative reasoning. Preliminary piloting yielded a Cronbach's alpha of .87, indicating acceptable internal consistency. Epistemic evaluation is measured by the *Evaluative Reasoning* subscale of the CEMLS (focusing on source credibility and misinformation) while ideological and structural critique is measured by the *Interpretive Competence* subscale of the CEMLS (focusing on power, hegemony, and narrative framing).

Environmental attitudes inventory (EAI). Derived from the validated Environmental Attitudes Inventory by Pauw et al. (2015), this 12-item instrument assesses affective orientations toward sustainability issues. It includes items on concern for biodiversity, climate justice, and ecological responsibility. Responses are recorded on a 7-point Likert scale. The scale has been previously validated for use in higher education contexts, with demonstrated construct validity and reliability ($a = .82$ in prior studies). Affective–Ethical Reflexivity is measured by the Environmental Attitudes Inventory (EAI) (focusing on ecological responsibility and climate justice).

Knowledge retention test (KRT). Developed specifically for this study, the KRT is a 15-item multiple-choice test based on the core content of the digital modules, including factual knowledge from the documentaries and interactive materials. It assesses students' comprehension and recall of key sustainability concepts, media narratives, and case-specific environmental data. The test was reviewed by two subject matter experts for content validity.

Behavioral intention Measure (BIM). This researcher-developed instrument includes 8 Likert-scale items assessing students' self-reported likelihood to engage in pro-environmental behaviors (e.g., sharing environmental content, participating in climate advocacy, reducing consumption). The BIM draws on the

Theory of Planned Behavior and serves as an outcome measure of the intervention's affective-behavioral impact. Pilot testing indicated satisfactory internal consistency ($a = .79$). Civic–Communicative Agency is measured by the Behavioral Intention Measure (BIM) (focusing on self-reported likelihood to engage in advocacy and communication).

The quantitative assessment was designed to operationalize selected aspects of the GEN-EML framework's four dimensions through a battery of complementary instruments. While the CEMLS serves as the primary tool for addressing the cognitive-critical dimensions (Epistemic Evaluation and Ideological Critique), the EAI and BIM were integrated to capture indicators associated with the internal-reflexive and external-agentic dimensions of the model, respectively. It should be acknowledged, however, that this multi-instrument approach offers only a partial operationalization of GEN-EML as a construct. The framework encompasses dimensions, particularly the affective and communicative, that resist straightforward quantitative capture, and the instruments employed here measure proxies and indicators rather than the dimensions themselves in their full theoretical scope. As such, the study should be understood as an initial attempt to bring the GEN-EML framework into contact with measurable outcomes, rather than as a comprehensive validation of the construct. Further instrument development and construct validation work will be necessary before GEN-EML can be considered fully operationalized in a psychometric sense.

Qualitative instruments. *Focus group interview protocol.* A semi-structured interview guide was developed to elicit students' reflections on their critical engagement with environmental documentaries and news media post-intervention. Questions focus on epistemic evaluation (e.g., "What made you trust or question this documentary?") and ideological positioning (e.g., "What kind of values did you perceive being promoted or omitted?"). The protocol was reviewed by two experts in media pedagogy and piloted with a small group for clarity and flow.

Document analysis tasks. Students in the experimental group will be asked to write brief critical responses (300–500 words) to a selected environmental news article and a short documentary excerpt both before and after the intervention. These documents will be analyzed for depth of critique, use of media literacy vocabulary, and ideological awareness. Changes in rhetorical complexity and evaluative stance will be used as indicators of epistemic and ideological development.

Together, these instruments enable a robust and multidimensional assessment of the students' learning outcomes, aligned with the theoretical and pedagogical goals of the study.

Procedure

The study will be conducted over a period of **four weeks**, with distinct phases for baseline assessment, intervention, and post-intervention evaluation. The procedure is designed to align with the convergent mixed methods design, ensuring that both quantitative and qualitative data are collected in parallel for triangulation.

Phase 1: Pre-intervention assessment

Prior to the intervention, all participants ($n = 60$) will complete the Critical Environmental Media Literacy Scale (CEMLS), the Environmental Attitudes Inventory (EAI), and the Knowledge Retention Test (KRT) to establish baseline levels. Additionally, students in the experimental group will complete a pre-intervention document analysis task, providing written critiques of an assigned environmental news article and documentary excerpt. This step enables measurement of their initial interpretive and evaluative capacities.

Phase 2: Intervention

The experimental group ($n = 30$) will participate in a four-week instructional program built around documentary-based digital learning modules and interactive sustainability-themed media platforms. The modules will include:

- Weekly screenings of award-winning environmental documentaries (e.g., *Before the Flood*, *Our Planet*), each followed by guided discussion prompts and reflective activities.
- Interactive learning components such as:
- VR simulations of climate change impacts (e.g., rising sea levels, deforestation)
- Gamified sustainability challenges (e.g., resource management simulations)
- Infographic creation tools to represent ecological data narratives

Instructional content will be delivered through a Learning Management System (LMS), supplemented by asynchronous discussion forums and structured media critique assignments. Activities will be designed according to constructivist and critical pedagogical principles, encouraging students to actively construct knowledge and question dominant media discourses.

In contrast, the control group ($n = 30$) will follow the standard curriculum of the media studies course, which includes foundational concepts in media literacy (e.g., media effects theory, advertising analysis) but does not integrate sustainability themes or digital documentary content.

Phase 3: Post-intervention assessment

At the conclusion of the four-week period, all participants will retake the CEMLS, EAI, and KRT. The Behavioral Intention Measure (BIM) will also be administered as a post-test only, gauging students' readiness to act on sustainability concerns.

Additionally, students in the experimental group will complete the post-intervention document analysis task, responding to a new set of media materials using the same format as the pre-task. A subsample of 10 students from the experimental group will participate in a focus group interview, conducted by a trained facilitator, to explore their perceptions of media credibility, ideological framing, and the educational value of the intervention. Interviews will be audio-recorded and transcribed verbatim for analysis.

This structured, multistage procedure is designed to ensure internal validity in the quantitative strand and theoretical saturation in the qualitative strand, thereby reinforcing the integrity and credibility of the study's findings.

Data analysis

In line with the convergent mixed methods design, quantitative and qualitative data will be analyzed independently and then integrated during interpretation to provide a comprehensive understanding of the impact of documentary-based digital learning tools on communication students' environmental media literacy.

Quantitative analysis

Quantitative data from the CEMLS, EAI, KRT, and BIM instruments will be analyzed using IBM SPSS Statistics v28. Prior to analysis, data will be screened for normality, missing values, and outliers. Descriptive statistics (means, standard deviations) will be reported for each measure at pretest and post-test stages.

To evaluate the intervention's impact:

- Paired sample t-tests will be conducted within each group to assess changes over time in media literacy, environmental attitudes, and knowledge retention.
- Analysis of Covariance (ANCOVA) will be performed to compare post-test scores between the experimental and control groups, using pretest scores as covariates. This approach allows for adjustment of initial group differences and provides a clearer estimate of the intervention effect.
- Effect sizes (Cohen's d) will be calculated for all significant results to assess the practical significance of observed differences.

All inferential tests will use an alpha level of .05. Assumptions of ANCOVA (e.g., homogeneity of regression slopes) will be checked, and nonparametric alternatives (e.g., Wilcoxon signed-rank test) will be used if assumptions are violated.

Qualitative analysis

Qualitative data, including focus group transcripts and pre/post document analysis texts, will be examined using thematic analysis as outlined by Braun and Clarke (2006). The process will involve:

1. Familiarization with data through repeated readings
2. Initial coding of data segments
3. Identification and refinement of themes
4. Review of themes for coherence and alignment with research questions
5. Final definition and naming of thematic constructs

To enhance credibility and trustworthiness, two independent coders will analyze the qualitative data. Intercoder agreement will be assessed using Cohen's kappa, aiming for a value of at least .70. Any discrepancies will be resolved through discussion and consensus. MAXQDA software will be employed to facilitate the organization and coding of qualitative data.

The analysis will focus on two thematic axes:

- Epistemic evaluation—students' judgments about the credibility, bias, and evidential quality of environmental media
- Ideological critique—students' recognition of underlying values, political framings, and power dynamics within media narratives

Results from both the quantitative and qualitative strands will be integrated in the discussion section through triangulation, identifying convergence, divergence, and complementarity across data types.

Interpreting the magnitude of observed effects

The interpretation of the substantial effect sizes observed in this study must be tempered by several contextual factors that may have amplified short-term gains. While the intervention produced significant shifts in literacy and attitudes, these results were achieved through intensive engagement within a concentrated four-week window, potentially benefiting from high levels of instructor enthusiasm and the structured nature of the digital facilitation. Furthermore, the collaborative environment created by cohort-level discussion dynamics, alongside testing familiarity and the inherent "Hawthorne" or novelty effects of using immersive digital tools, may have contributed to the elevated performance. Crucially, because the study design did not include delayed post-tests, it remains impossible to determine the extent to which these gains would persist over an extended duration. Consequently, these findings should be interpreted as robust evidence of immediate learning enhancement rather than definitive proof of durable, long-term cognitive or identity transformation.

Ethical considerations

This study followed high ethical standards in educational and social science research. Ethical approval was obtained from the host university's Institutional Review Board (IRB) numbered 000158502 prior to data collection, and all procedures aligned with the Declaration of Helsinki and the American Psychological Association's Ethical Principles and Code of Conduct. Participation was voluntary, and students were informed they could withdraw at any time without penalty. Before enrollment, participants reviewed an electronic informed consent form describing the study purpose, data use, confidentiality protections, and the non-evaluative nature of participation. Digital consent was collected and stored securely. Data were handled confidentially. Participant identities were anonymized using coded identifiers, and identifying details were removed from qualitative transcripts. All quantitative and qualitative data were stored on password-protected servers accessible only to the research team. To reduce power imbalances and avoid coercion, participation was not linked to course credit or academic benefit, and instructors delivering the content were not involved in data analysis. Control-group students received access to all digital

learning materials after the study to ensure equitable benefit. These measures protected autonomy, supported data integrity, and promoted transparency.

Findings

Table 2 presents the descriptive statistics for the Critical Environmental Media Literacy Scale (CEMLS) scores obtained from both the experimental and control groups at pretest and post-test. At baseline, mean CEMLS scores were comparable between the experimental group ($M = 80.17$, SD = 3.13) and the control group ($M = 78.93$, SD = 2.10). Following the four-week intervention, the experimental group recorded a notably higher post-test mean ($M = 90.07$, SD = 2.31) compared to the control group ($M = 80.03$, SD = 1.91). While these descriptive patterns indicate a directional difference favoring the intervention condition, the magnitude of the observed change warrants careful interpretation, as the design features of this study, including its short duration, small sample size, and the use of proximal outcome measures, are conditions known to inflate apparent gains.

Paired-sample t-tests revealed statistically significant improvements in CEMLS scores for both groups from pretest to post-test. The experimental group showed a large gain, t(29) = 21.84, $p < .001$, Cohen's $d = 3.99$, while the control group also improved, t(29) = 6.04, $p < .001$, Cohen's $d = 1.10$. An ANCOVA controlling for baseline scores confirmed a significant group difference, F(1,57) = 622.45, $p < .001$, partial n2 = .92. However, effect sizes of this magnitude, particularly $d = 3.99$, are highly atypical in educational research, where values in the range of $d = 0.4$ to 0.8 are more commonly reported for well-designed interventions. These figures should therefore be interpreted with considerable caution. It is likely that they represent inflated estimates shaped by study design features: the four-week duration limits exposure to regression toward the mean; the proximal measures were developed specifically to align with intervention content, reducing the construct distance that typically attenuates effect sizes; the small cohort of 30 participants per group increases sampling variability; and novelty and demand effects in a short experimental setting may have heightened participant responsiveness beyond what would be sustained over time.

Environmental Attitudes Inventory (EAI) scores at pretest were similar for the experimental group ($M = 58.23$, SD = 2.52) and the control group ($M = 56.17$, SD = 2.22). Following the intervention, the experimental group's mean increased to $M = 67.57$ (SD = 1.88), while the control group showed a smaller increase to $M = 58.17$ (SD = 1.91). Paired-sample t-tests indicated significant within-group gains for both the experimental group, t(29) = 20.64, $p < .001$, $d = 3.77$, and the control group, t(29) = 7.52, $p < .001$, $d = 1.37$. The ANCOVA confirmed a significant group difference, F(1,57) = 516.72, $p < .001$, partial n2 = .90. As with the CEMLS results, effect sizes at this scale ($d = 3.77$) are implausible as stable estimates of true intervention effectiveness and are better understood as design-sensitive artifacts rather than reliable indicators of the intervention's impact on environmental attitudes.

Knowledge Retention Test (KRT) scores followed a similar pattern. At pretest, the experimental group scored $M = 8.53$ (SD = 1.05) and the control group $M = 8.17$ (SD = 1.14). Post-test results showed a larger increase for the experimental group ($M = 12.93$, SD = 0.94) than for the control group ($M = 9.07$, SD = 1.02). Paired-sample t-tests revealed significant improvements in both groups: experimental group, t(29) = 20.12, $p < .001$, $d = 3.67$; control group, t(29) = 5.72, $p < .001$, $d = 1.04$. The ANCOVA confirmed a significant group difference, F(1,57) = 584.39, $p < .001$, partial n2 = .91. Again, the effect size for the

Table 2. Descriptive statistics and paired-sample *t*-test results for experimental and control groups.

Measure	Group	Pretest M (SD)	Post-test M (SD)	*t*(df)	*p*	Cohen's *d*
CEMLS	Exp	80.17 (3.13)	90.07 (2.31)	21.84 (29)	< .001	3.99
	Ctrl	78.93 (2.10)	80.03 (1.91)	6.04 (29)	< .001	1.10
EAI	Exp	58.23 (2.52)	67.57 (1.88)	20.64 (29)	< .001	3.77
	Ctrl	56.17 (2.22)	58.17 (1.91)	7.52 (29)	< .001	1.37
KRT	Exp	8.53 (1.05)	12.93 (0.94)	20.12 (29)	< .001	3.67
	Ctrl	8.17 (1.14)	9.07 (1.02)	5.72 (29)	< .001	1.04

Note. Exp: Experimental group; Ctrl: Control group. CEMLS: Critical Environmental Media Literacy Scale; EAI: Environmental Attitudes Inventory; KRT: Knowledge Retention Test.

experimental group is exceptionally large by the standards of educational research and should be read as a likely overestimate. The KRT's close alignment with the specific content delivered during the intervention period further increases the risk that scores reflect familiarity with recently encountered material rather than durable knowledge acquisition.

As Table 3 displays, the experimental group outperformed the control group across all three outcome measures, with statistically significant group differences observed for environmental media literacy, environmental attitudes, and knowledge retention. Both groups showed within-group gains from pretest to post-test, with larger changes consistently recorded among students in the intervention condition. That said, the effect sizes obtained across all three measures, ranging from $d = 3.67$ to $d = 3.99$ for the experimental group, are well outside the range typically observed in educational intervention research and cannot be taken at face value as indicators of intervention strength. Taken together, the results offer preliminary directional evidence that the documentary-based digital modules were associated with positive outcomes on proximal measures, but the findings should be understood as exploratory rather than confirmatory. Replication with larger samples, greater construct distance between intervention content and outcome measures, and longer follow-up intervals will be necessary before more confident conclusions about effectiveness can be drawn.

Interpreting the magnitude of observed effects

The remarkably large effect sizes observed in this study ($d > 3.5$ for all primary measures) require careful contextualization. While these figures suggest a powerful intervention, they likely reflect a confluence of factors beyond the pedagogical efficacy of the GEN-EML framework.

Measurement sensitivity and curriculum alignment

The magnitude of these gains may be partially attributed to high **curriculum-test alignment**. Because the CEMLS and KRT instruments were specifically designed to capture the unique dimensions of the GEN-EML model, there may be a high degree of overlap between the intervention content (the documentary and digital modules) and the assessment items. In educational evaluation, when a test is highly "proximal" to the instructional material, effect sizes are frequently inflated compared to "distal" or standardized measures.

Pretest sensitization and testing familiarity

The significant gains observed in the control group ($d = 1.04$ to 1.37) suggest a strong testing effect. The use of identical instruments for pre- and post-testing within a narrow four-week window likely allowed for "pre-test sensitization," where the initial assessment signaled to students which concepts were important, thereby narrowing their focus during the intervention. This familiarity often results in artificial score inflation that does not necessarily represent a deep cognitive shift.

Small sample size and sampling error

With a sample of $N = 30$ per group, the study is susceptible to the "magnitude gap" often found in small-scale pilots. Small samples are more likely to yield exaggerated effect sizes due to sampling error and the

Table 3. ANCOVA results comparing experimental and control groups on post-test scores controlling for pretest.

Measure	*F*(1,57)	*p*	Partial n2
CEMLS	622.45	< .001	.92
EAI	516.72	< .001	.90
KRT	584.39	< .001	.91

lack of "regression to the mean" that occurs in larger, more diverse populations. These results should therefore be viewed as a "proof of concept" rather than a precise estimate of population-level impact.

Ecological validity and intensive facilitation

The "Hawthorne effect" was likely amplified by the high-fidelity nature of the digital facilitation and the intensive, cohort-based discussion dynamics. In such a concentrated environment, the "novelty effect" of immersive digital tools can create an immediate, high-magnitude response in student engagement. While these findings provide robust evidence of immediate learning enhancement, they cannot yet be interpreted as evidence of durable, long-term identity transformation or permanent shifts in communicative agency.

Qualitative data came from (1) a post-intervention focus group with a purposive subsample of ten experimental-group students and (2) pre/post written media critiques from all experimental participants. The focus group captured shared reflections on engaging with environmental narratives, while the critiques documented individual shifts in interpretation and evaluative reasoning. Participants reflected diverse gender, age, and academic standing, and all completed the four-week module and related activities before contributing.

A central theme, displayed in Table 4, was *epistemic evaluation* which points to how students judged credibility, accuracy, and evidence quality in environmental media. Pre-intervention, written critiques often accepted documentary narratives at face value, with limited attention to sourcing or corroboration. Post-intervention, students reported more systematic verification: cross-checking claims against scientific reports, questioning producer motives, and scrutinizing visuals and statistics for bias. This pattern suggests the intervention fostered not only accuracy awareness but also a sustained habit of critically interrogating environmental media representations.

Shown in Table 5, a second major theme was *ideological critique*, reflecting students' capacity to identify the values, political framings, and power relations embedded in environmental media narratives. Before

Table 4. Theme 1: Epistemic evaluation—representative student quotes from focus group discussion.

Subtheme	Representative quote	ID
Source credibility assessment	"Before, I just assumed documentaries were fact-checked. Now I check who produced it, who funded it, and whether they cite real studies."	P4
Cross-referencing with other sources	"I looked up some of the statistics from the documentary and found different numbers in UN reports. That made me question why they chose certain data."	P7
Detection of selective framing	"They focused a lot on dramatic imagery but didn't show the counter-arguments. That made me think about what they wanted us to believe."	P2
Verification of visual evidence	"I realized some images were taken in different contexts than the narration suggested. That was eye-opening for me."	P9

Table 5. Theme 2: Ideological critique—representative student quotes from focus group discussion.

Subtheme	Representative quote	ID
Detection of dominant narratives	"The film mainly showed Western scientists and ignored indigenous perspectives. That made me think about whose story is being told."	P5
Recognition of political framing	"It portrayed renewable energy as the only solution without talking about reducing consumption, which felt politically convenient."	P3
Identification of economic interests	"I noticed the sponsor was a big tech company, and their solutions were the ones promoted in the documentary."	P6
Critique of omission	"They never addressed the role of big corporations in causing the problem, which made me question the neutrality of the film."	P1

the intervention, written critiques rarely addressed ideology; students typically focused on the environmental issue itself rather than asking whose interests were prioritized or silenced. After the intervention, focus group participants showed greater awareness that environmental messages are shaped by cultural, political, and economic agendas. They noted, for example, how some documentaries centered Global North perspectives while marginalizing Global South voices, and how corporate sponsorship could subtly shape messaging. Students also observed that certain texts favored neoliberal or technocentric "solutions" while downplaying structural critiques of industrial capitalism. Overall, this shift signals a move from surface interpretation and fact-checking toward deeper socio-political analysis.

The third theme as presented in Table 6, *reflexive engagement*, describes how students related environmental media messages to their own values, lifestyles, and intentions for action. Before the intervention, most written critiques showed little self-reflection and treated environmental issues as distant problems best solved through policy or technology. After the intervention, students more often framed these challenges as personally relevant, connecting documentaries to their consumption habits, career goals, and civic responsibilities. Focus group participants also reported increased agency, including intentions to change behaviors (e.g., reducing single-use plastics, joining community clean-ups) and to produce environmentally focused media content. Overall, this shift from passive awareness to proactive consideration of change suggests a deeper integration of the cognitive, affective, and behavioral dimensions of environmental media literacy.

Analysis of the written critiques showed a clear shift from descriptive summary to more critical, theory-informed analysis. Before the intervention, most students mainly recounted key points from the documentary or article, with limited interrogation of claims, framing, or ideology. When evaluation appeared, it tended to be broad (e.g., "informative") and rarely referenced evidence, source credibility, or alternative viewpoints.

After the intervention, critiques displayed stronger argument structure and more frequent use of critical media literacy concepts. Students identified framing devices such as selective statistics, emotional imagery, and omitted counter-narratives, and they increasingly questioned producer intent, situated messages in wider socio-political contexts, and cross-checked claims with scientific or independent sources. Reflexive elements also increased, with students connecting content to personal values, lifestyle choices, and future professional responsibilities. Overall, the progression suggests the intervention strengthened epistemic and ideological awareness and helped students apply these capacities through reflective practice beyond the immediate learning task.

The qualitative findings also aligned closely with the quantitative results, reinforcing the conclusion that the intervention produced substantial gains in environmental media literacy, environmental attitudes, and sustainability-related knowledge retention. Reported growth in epistemic evaluation mirrored increases in CEMLS scores, indicating more systematic credibility assessment and verification strategies. The rise of ideological critique in post-intervention narratives corresponded with higher EAI scores, suggesting attitudinal development included greater awareness of political and cultural forces shaping environmental communication. Reflexive engagement, especially intentions to adopt sustainable behaviors and integrate environmental responsibility into media practice, was consistent with stronger behavioral intention measures and improved KRT performance, reflecting both better factual grasp and clearer practical implications.

Table 6. Theme 3: Reflexive engagement—representative student quotes from focus group discussion.

Subtheme	Representative quote	ID
Personal relevance	"It made me think about my own carbon footprint, like how much I travel and what I eat."	P8
Behavior change intention	"I've started bringing my own reusable bottle and avoiding single-use cups."	P10
Professional responsibility	"As a future journalist, I feel like I should report on climate issues more carefully."	P4
Civic engagement	"I joined a local environmental group after watching those documentaries."	P7

Taken together, the qualitative evidence shows how documentary-based digital modules and interactive sustainability media can deepen communication students' engagement with environmental narratives. Students moved from surface description to critical interrogation, became more attentive to ideological framing, and more often linked sustainability to personal and professional responsibility given the limited discourse of the intervention is considered. These were not isolated cognitive gains: they were accompanied by attitudinal shifts and concrete behavioral intentions, within the boundaries of the four-week course. Consistent with the quantitative improvements across media literacy, attitudes, and retention, the qualitative themes suggest the intervention functioned as both a cognitive and affective catalyst, preparing students to critically analyze, ethically produce, and meaningfully act on environmental media content.

Discussion & conclusion

The convergence of quantitative and qualitative results indicates that a documentary-based digital learning intervention can build communication students' sustainability capacities in academically and professionally meaningful ways. Gains in environmental media literacy, attitudes, and knowledge retention demonstrate growth across cognitive and affective dimensions, consistent with multidimensional definitions of environmental literacy that integrate cognitive, affective, and behavioral components (Jia & Wang, 2024). Qualitatively, learning clustered around epistemic evaluation, ideological critique, and reflexive engagement, together positioning EML as a holistic competence relevant to ethical reasoning and professional preparedness, and aligning with broader goals of embedding the SDGs in higher education (Underwood et al., 2025).

These findings strengthen the case for environmental media literacy as a distinct construct, rather than an additive combination of existing fields. While general and digital media literacy highlight access, evaluation, and participatory competence (Livingstone, 2004; Mihailidis & Thevenin, 2013; Scheibe & Rogow, 2012), and critical media literacy emphasizes ideology and power (Funk et al., 2016; Kellner & Share, 2005, 2007), neither was designed to address the specific condition in which learners encounter environmental crises primarily through algorithmically curated, affectively charged digital media (Treen et al., 2020). The distinction is not that these traditions ignore the relevant material but, as Table 1 demonstrated, that applied to a single mediated controversy they return incompatible verdicts—"reject" on accuracy grounds, "embrace" on ideological grounds, "mobilise" on participatory grounds—which their combination cannot reconcile. By demonstrating simultaneous gains in verification, interpretive critique, and values-based orientation, the present findings support EML as an integrated capacity that aligns epistemic rigor with ecological ethics and civic responsibility (Campbell et al., 2021), addressing the mutual incompleteness of these traditions (Göçen & Bulut, 2024; Ghazaali, 1100).

The results further suggest that epistemic evaluation and ideological critique operate as mutually reinforcing processes rather than discrete skills. Students' stronger fact-checking was intertwined with greater awareness of framing, omissions, and value-laden assumptions, consistent with the view that mediated environmental knowledge is shaped by strategic narratives rather than neutral reporting (Elhüseyni, 2025; Kellner & Share, 2007; Supran & Oreskes, 2021). This pattern maps onto the integrating logic the framework predicts and that Table 1 illustrates: under conditions of algorithmic mediation, credibility assessment and ideological analysis are not separable competencies but two readings of one object. The observed integration is consistent, moreover, with a substantial body of evidence indicating that resistance to environmental misinformation is built most durably not through post-hoc correction but by equipping learners to recognize manipulation techniques in advance—the logic of psychological inoculation, or "prebunking" (van der Linden et al., 2017). Active, experiential designs in which learners themselves construct or deconstruct misleading content appear especially effective at conferring such resistance (Roozenbeek & van der Linden, 2019), which lends theoretical support to the production-oriented design of the present intervention. In this sense, GEN-EML functions as more than a set of literacy skills: by intertwining verification with an analysis of power, students moved beyond superficial debunking toward a structural understanding of why certain narratives are algorithmically amplified (Treen et al., 2020). For future communication professionals, the ability to identify greenwashing and

manufactured doubt (Supran & Oreskes, 2021) is no longer an optional ethical stance but a core technical requirement for maintaining public trust in environmental discourse.

What the parent traditions cannot specify, and GEN-EML does, is that this defensive competence culminates in production. Critical media literacy interrogates social representation but frequently treats the environment as background rather than as a dynamic system whose communication is mediated through contested digital infrastructures. Action competence frameworks address socio-political intervention but do not specify the communicative agency required to navigate manufactured doubt and ideological framing in digital environments (Jensen & Schnack, 1997). GEN-EML addresses this gap by treating environmental knowledge as a contested site of algorithmic mediation and by positioning the learner as a node within a socio-technological ecology where the health of the information stream is inseparable from the health of the biosphere. The integration of Affective–Ethical Reflexivity and Civic–Communicative Agency (Dimensions 3 and 4) further addresses a gap in existing measurement tools (Irvin et al., 2019; Rohlman et al., 2022), which seldom register the emotional paralysis induced by mediated ecological narratives—what Li Mandri (2026) describes as psychological disavowal within the metacrisis. Situated alongside connectivist principles, the framework prioritizes distributed cognition and the mapping of power structures over rote learning, aligning with posthumanist orientations that decenter human exceptionalism (Jordan & Jónsson, 2025).

Pedagogically, documentaries proved effective because they combine environmental content with a persuasive media form, prompting learners to interrogate narrative, evidence, and framing simultaneously. This supports work showing that eco-documentaries deepen scrutiny of conservation narratives (Liu, 2018; Mliless & Azzouzi, 2020) and that emotionally resonant media shapes knowledge, behavior, and self-reflection (Dunn et al., 2020; Fernández-Bellon & Kane, 2020). The digital design is consistent with evidence that interactive multimedia supports active knowledge construction and critical thinking (Adiguzel et al., 2023; Bulut, 2026; Gunawan et al., 2020; Nanda & Budimansyah, 2020; Yurdunkulu et al., 2025) and that inquiry-oriented platforms improve understanding of complex systems (Birgili et al., 2025; Susilawati et al., 2022).

The implications of these findings, while promising, should be understood as grounded in short-term, context-specific learning gains rather than as evidence of durable competence development. For environmental communication education, EML is better understood as a core career-preparatory competence than a peripheral topic (Christensen, 2023), and the shifts observed here suggest that even a brief, structured intervention may begin to orient students toward communicative agency—positioning them not as neutral messengers but as active shapers of the socio-ecological information stream. Whether such orientations persist beyond the instructional context remains an open question. Curriculum designs that combine guided verification and framing analysis with reflective, career-linked production tasks may support the development of job-relevant competencies across journalism, strategic communication, digital production, advocacy, and sustainability communication (Karanfiloğlu & Bulut, 2025; Lintangsari et al., 2023), though the present study can speak only to immediate shifts on proximal measures rather than to the consolidation of such competencies over time. Peer dialogue and participatory projects reinforce democratic, co-creative orientations associated with digital literacy (Mihailidis & Thevenin, 2013), while community-oriented learning grounds sustainability storytelling in lived ecological contexts (Mukoni, 2015).

At institutional and policy levels, the findings offer preliminary support—subject to the constraints of a single-program, short-duration design—for embedding EML outcomes into program competencies and quality frameworks, strengthening interdisciplinary collaboration across communication, environmental science, and education (Adiguzel et al., 2023; Bulut et al., 2025; Lozano et al., 2023; Sammalisto et al., 2016), and forging partnerships with NGOs and media organizations to provide authentic civic storytelling contexts. These possibilities are best treated as directions for curriculum development rather than conclusions the present data can directly substantiate.

Despite its pilot-study nature, and although this study focused on communication majors, the documentary-based GEN-EML framework is readily adaptable across disciplinary contexts (Bulut et al., 2026; Kaya et al., 2026a, 2026b; Li Mandri 2026). In environmental science programs, it could bridge data literacy and narrative literacy, equipping scientists to translate ecological data into media forms that resist ideological distortion. In political science, it could support analysis of how digital

echo chambers constrain environmental policy-making (Treen et al., 2020). The framework's modularity—combining epistemic, ideological, affective, and civic dimensions—means individual components can be scaffolded into existing curricula without wholesale redesign.

To restate the distinction directly: traditional environmental literacy often centers scientific knowledge and individual behavior but gives limited attention to how digital algorithms and political economy distort that knowledge; critical media literacy addresses social representation but tends to treat the environment as a static backdrop; and action competence models are frequently oriented toward local, physical interventions. GEN-EML addresses communicative agency—the capacity to navigate and disrupt the manufactured doubt and algorithmic amplification that obstruct action at the level of the information environment itself (Rahman et al., 2026; Supran & Oreskes, 2021; Treen et al., 2020; Yurdunkulu, 2026). It is not simply teaching people about nature, but attending to how digital systems and ecological systems are now inextricably entangled. While components of GEN-EML draw from established traditions, the framework advances an integrative orientation specifically directed at the co-evolution of ecological breakdown and digital disinformation—a conjunction that existing frameworks, as Table 1 showed, address only partially and in mutual contradiction.

Key limitations remain. The single-program setting limits generalizability, and the short intervention window restricts any claims about long-term retention or durable behavior change (Witek & Grettano, 2014). Future research should replicate across institutions and cultural contexts, include structured production tasks to test whether critique translates into professional-quality outputs, and incorporate comparison-group qualitative data. Immersive technologies may further deepen embodied and affective learning, as VR experiences have been linked to reflective engagement and intensified scrutiny of environmental narratives (Ruan, 2022). The reliance on adapted instruments (CEMLS, EAI, BIM) also warrants attention: while their combination provides a holistic proxy for the four-dimensional framework, future work should develop a natively integrated GEN-EML scale capable of capturing the friction between digital connectivism, ecological ethics, and posthumanist epistemology that current instruments only partially register. The instruments employed operationalize selected aspects of the framework's four dimensions rather than capturing the construct in its full theoretical scope; dimensions such as the affective and the communicative are not readily reducible to quantitative indicators, and the measures used here should be understood as proxies rather than comprehensive assessments. Robust construct validation remains a priority for future work.

Ultimately, the study's findings suggest that addressing the ecological metacrisis requires a pedagogy that accounts for the entanglement of digital code, human ideology, and eco-biological systems. By fostering a self-understanding grounded in more-than-human relationality, and by equipping students to adjudicate and then responsibly re-produce environmental media, GEN-EML offers a viable domain in which to prepare a new generation of communicators for a world where the boundaries between information ecology and ecological reality have permanently blurred.

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Compliance with ethical statement

Authors declare no conflict of interest.

Consent to participate

Participants were informed about the purpose of the study, the voluntary nature of their participation, and their right to withdraw at any time without consequence. Informed consent was obtained electronically prior to data collection. No personally identifiable information was collected.

Consent to publish

Not applicable. This study does not contain any individual person's data in any form (including individual details, images, or videos) that would require consent to publish.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Informed consent

Informed consent has been received from participants.

Ethical approval statement

IRB approval was received from Ibn Haldun University Human and Social Sciences Ethical Review Board Numbered 278877-2025/08.

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Data availability statement

Data could be provided upon reasonable request from the corresponding author.

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