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Revitalizing the Potential of CALL with an Ecological Twist: The Impact of an Ecolinguistically-based Task in Fostering Ecological Sustainability Perspectives among EFL Learners

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ABSTRACT

Background and Objectives: In response to the burgeoning significance of environmental and sustainability education, the educational landscape is undergoing rapid transformations, presenting new opportunities for foreign language classrooms to assume a distinctive role in exposing learners to the fundamental concepts and principles of environmental literacy. Drawing on a newly constructed Ecolinguistic computer-assisted language learning (CALL) evaluation scale, this study aims to investigate the implementation of this scale and the interplay between language, centering on an Ecolinguistically-based task that illustrates the interaction between and among the affordance of technology, the teacher participant's pedagogical considerations and their goal of encouraging learner agency in nurturing learners' ecological perspectives, content aspects, and competency of environmental knowledge.

Methods: A sequential explanatory mixed-methods design was adopted to implement a newly constructed Ecolinguistic CALL perspective to promote environmental literacy among foreign language learners. Two intact classes, including 30 English foreign language learners, were randomly assigned to investigate the implementation of the subscales. A paired-sample t-test was applied to analyze the quantitative data. As part of implementing the Ecolinguistic scale and qualitative data analysis, the participants were assigned an Ecolinguistically technology-based task and were informed about the fundamental concepts of the subscale domains of environmental literacy using a technology-mediated task. Thematic analysis was run to gain a more robust view of the participants' ecological views.

Findings: The study findings unveil a notable and affirmative influence on students' ecological perspectives, as evidenced by the rigorous quantitative data analysis and the participants' thematic analysis reflections. The successful implementation of the Ecolinguistic subscales and the Ecolinguistically-based task significantly bolstered learners' ecological perspectives while concurrently enhancing their comprehension of intricate ecological concepts. These outcomes substantiate the proposition that integrating Ecolinguistic dimensions into technology-mediated pedagogies holds promising potential for cultivating environmental literacy among English foreign language learners.

Conclusions: This research highlights the need to reconceptualize environmental challenges and problematizes the traditional positivist framework underlying mainstream linguistic inquiry. It accentuates the significance of thoughtfully integrating appropriate technologies into language learning environments to enrich students' learning experiences and stimulate motivation that aligns with their individual interests. Moreover, the study underscores the importance of employing practical and cost-effective evaluation techniques to assess students' environmental literacy. The findings yielded by this research endeavor will facilitate and advocate for embracing an eco-dimensional strategy that harmonizes numerous concerns about the volatility of the human habitat and the augmentation of the ecosystem's capacities via the integration of technical concepts, methodologies, and linguistic analysis techniques. This approach endows us with universally applicable to implementing humanitarian endeavors through CALL. It furnishes invaluable perspectives that enrich our comprehension of environmental literacy, thereby bolstering the efficacy of decision-making processes in enhancing our grasp of transformative endeavors within the realms of curriculum design and policy. Several noteworthy limitations warrant consideration. Primarily, the investigation failed to acknowledge the potential ramifications of additional constructs on the subscales of the Ecolinguistic scale. Secondly, the inquiry into the environmental literacy of the participants surpassed the confines of the study's purview. Notwithstanding these limitations, the study's findings and methodologies have propelled our comprehension of environmental literacy to new heights. Nonetheless, further measures are imperative to bolster curriculum design and policy formulation decision-making processes. The study carries substantial implications for pedagogy and academia, encompassing the enhancement of environmental literacy among English as a Foreign Language learners and the cultivation of a comprehensive approach to language acquisition. Additional research is indispensable to delve into the pedagogical preferences of educators, regulate variables, and encompass a more expansive sample size. Educators are strongly encouraged to adopt student-centered, transformative pedagogies while simultaneously ensuring equitable access to technology-driven resources. A thorough understanding of sociolinguistics and a thoughtful consideration of technological affordances also assume pivotal roles in this endeavor.

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
49	1	5

مقاله پژوهشی

تقویت ظرفیت یادگیری زبان به کمک رایانه با پیچ و تاب زیست محیطی: تأثیر یک تکلیف مبتنی بر رویکرد زبان شناسی زیست محیطی به کمک فناوری در تقویت دیدگاه های پایدار زیست محیطی در بین فراگیران زبان انگلیسی

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چکیده

پیشینه و اهداف: در پاسخ به اهمیت روزافزون آموزش های زیست محیطی پایدار، چشم انداز های آموزشی دستخوش دگرگونی های سریعی می شود و فرصت های جدیدی را برای کلاس های درس زبان های خارجی ارائه می کند تا نقشی متمایز در آشنا کردن زبان آموزان با مفاهیم و اصول اساسی سواد زیست محیطی ایفا کنند. این پژوهش با بهره گیری از مقیاس توسعه یافته جدید ارزشیابی یادگیری زبان به کمک کامپیوتردر زبان شناسی زیست محیطی، با هدف بررسی و پیاده سازی این مقیاس و تأثیر متقابل آن با زبان و با تکیه بریک تکلیف درسی مبتنی بر زبان شناسی زیست شناختی که تعامل بین زبان زیست شناختی و فناوری را نشان می‌دهد، صورت گرفته است. ملاحظات آموزشی معلمان شرکت کننده و هدف آن‌ها از تشویق جنبه‌های عاملیت فراگیران در پرورش دیدگاه‌های زیست شناختی، جنبه‌های محتوایی و توانایی دانش زیست محیطی آن ها را نشان می‌دهد.

روش‌ها: یک طرح تحقیق ترکیبی توضیحی متوالی برای پیاده‌سازی دیدگاه یادگیری زبان به کمک رایانه در زبان شناسی زیست محیطی برای ارتقاء سواد زیست محیطی در بین زبان‌آموزان اتخاذ شد. دو کلاس خارج از طرح کنترل شامل ۳۰ دانشجو ی زبان انگلیسی به طور تصادفی به بررسی اجرای خرده مقیاس ها اختصاص داده شدند. برای تجزیه و تحلیل داده های کمی از آزمون تی زوجی استفاده شد. به عنوان بخشی از اجرای زبان شناسی زیست محیطی و تجزیه و تحلیل داده‌های کیفی، به شرکت‌کنندگان یک تکلیف آموزشی مبتنی بر مفاهیم زیست محیطی به کمک فناوری محول شد که در آن دانشجویان در مورد مفاهیم اساسی حوزه‌های خرده مقیاس سواد زیست‌محیطی آگاهی یافتند. همچنین برای به دست آوردن یک دیدگاه قوی‌تر از دیدگاه های زیست محیطی، تجزیه و تحلیل موضوعی از شرکت کنندگان به عمل آمد.

یافته‌ها: نتایج مطالعه تأثیر قابل‌توجه و مثبتی بر دیدگاه‌های زیست‌محیطی دانشجویان نشان داد، کمابنکه تحلیل دقیق داده‌های کمی و بازتاب تحلیل موضوعی شرکت‌کنندگان نیز حاکی ازین مسئله بود. اجرای موفقیت‌آمیز خرده مقیاس‌های زیست‌محیطی و تکلیف محوردر زبان‌شناسی به طور قابل‌توجهی دیدگاه‌های زیست‌محیطی دانشجویان را تقویت کرد و همزمان درک آن‌ها را از مفاهیم پیچیده اکولوژیکی افزایش داد. نتایج این گزاره اثبات می‌کند که ادغام ابعاد زبانشناسی زیست محیطی در آموزش های مبتنی بر فناوری ظرفیت امیدوارکننده ای برای پرورش سواد زیست محیطی در بین زبان آموزان است.

نتیجه‌گیری: این تحقیق بیانگر نیاز مبرم به مفهوم‌سازی مجدد و حل چالش‌های زیست محیطی می‌باشد و بیانگر چارچوب فلسفی مثبت و عملی سنت گرایی در جریان اصلی تحقیقات, می‌باشد. اهمیت ادغام متفکرانه فناوری‌های مناسب در محیط‌های فراگیری زبان برای غنی‌سازی تجربیات یادگیری دانش‌جویان و انگیزه آنان، همسو با علایق فردی شان می‌شود . لذا این مطالعه بیانگر اهمیت کاربرد تکنیک‌های ارزشیابی عملی برای ارزیابی سواد زیست محیطی

دانشجویان میباشد. نتایج این مطالعه، پذیرش یک استراتژی زیست‌بعدی را که نگرانی‌های مربوط به نوسانات زیستگاه انسانی و افزایش ظرفیت‌های اکوسیستم از طریق ادغام مفاهیم فنی، روش‌شناسی و زبان‌شناسی است را هماهنگ, تســـهیل و حمایت می‌کند. تکنیک های تجزیه و تحلیل این رویکرد ابزارهای قابل اجرای جهانی جهت تلاش‌های بشردوستانه از طریق فناوری به ما ارائه می‌دهد. تکنیک های تجزیه و تحلیل این رویکرد، ابزارهای قابل اجرای جهانی و دیدگاه های ارزشمندی را جهت تلاش‌های بشردوستانه از طریق فناوری به ما ارائه می کند تا درک ما از سواد زیست محیطی افزایش یابد و در نتیجه، کارایی فرآیندهای تصـمیم‌گیری ما در تقویت بینش مان از تلاش‌های تحول‌آفرین در حوزه‌های طراحی برنامه درسی و سیاست گذاری تقویت می شود. بررسی چندین محدودیت قابل توجه در این مطالعه اهمیت دارد. در ابتدا، این تحقیق نتوانست نتایج بالقوه دیگر ســازه‌ها را در خرده مقیاس‌های زبان شــناسی زیست محیطی تأیید کند. ثانیاً، تحقیق در مورد سواد زیست محیطی شرکت کنندگان از محدوده قلمرو مطالعاتی فراتر نرفت. علیرغم محدودیت‌ها، یافته‌های این مطالعه و روش‌شناسی، درک ما را از سواد زیست محیطی به افق های جدیدی سوق داده است. لذا، اقدامات بیشــتر برای تقویت فرآیندهای تصــمیم گیری در مورد طراحی برنامه درسی و ضرورت تدوین سیاست‌های مناسب احساس می‌شود. این مطالعه کاربردهای قابل توجهی برای آموزش و دانشگاه دارد که شامل افزایش سواد زیست محیطی در بین دانشجویان و پرورش یک رویکرد جامع برای فراگیری زبان است. تحقیقات بیشتری برای بررسی ترجیحات آموزشی مربیان، تنظیم متغیرها و در بر گرفتن حجم نمونه گسترده تر ضروری است. مربیان تشویق می‌شـوند تا آموزش‌های دانشـجو محور و نوآورانه را اتخاذ کنند و همچنین به منظور اطمینان از دسـترسـی عادلانه به منابع فناوری، تلاش نمایند.

Introduction

In recent years, there has been a surge of interest in incorporating computer-assisted language learning (CALL) programs to bolster learners' environmental literacy [1],[2],[3]. As an overarching domain of applied linguistics, CALL can be situated at the confluence of various academic disciplines [4]. In a parallel fashion, the interplay between language and communication has assumed a pivotal role in the realms of Linguistics and Language Education, constituting a salient domain of scrutiny that furnishes illuminating perspectives and direction for practical pedagogical approaches [5]. Linguistics, as a dynamic scientific field, adapts itself to the new systemic reality of ecology. This perspective can be split into dual variations; the initial postulates a clear demarcation between language and environment, whereas the latter presupposes their function as a complex system comprising interconnected entities [6].

As the field of Linguistics has progressed to a point, it no longer requires coddling from the sophistication and lucidity of information derived from reality. Rather, it actively seeks out novel methodologies to delve into the "actual" reality. As Larsen-Freeman posits, "this ecological orientation paves the way for the future" [7, p. 110], indicating that an ecological perspective in language teaching involves recognizing that learning is meaningful when students are instructed to embrace and encounter the language reality through pedagogical processes, affordances, and ecological artifacts. Seen in this way, learning a language entails undergoing a process of development that transforms human agency into fully functional agents with distinct characteristics.

Correspondingly, Ecolinguistics as a subfield of linguistics delves into the intricate relationship between language and the environment and opens up a novel trajectory in linguistics to extend the human vision of language and life [8]. From this angle, the study may further call for deeper assumptions of interdisciplinary domains, including CALL pedagogy, through theoretical, empirical, or experiential means. In light of this, it can be posited that the fundamental assumptions inherent in linguistic practices have the potential to shape one's attitudes and

behaviors toward the natural ecology as they reflect on the natural world and indicate that the field did not arise from a single investigation but evolved in collaboration with external aspects of the environment and animal world [9]. Furthermore, integrating Ecolinguistic facets into CALL-based pedagogies may challenge instructors to commit themselves to this new educational vision and redefine their views of teaching practices.

The rapidly escalating deterioration of our natural environment has necessitated a critical reassessment of the positivist framework that has traditionally underpinned mainstream linguistic inquiry. Steffensen and Fill [10] argue that the conventional notion of science as a linear progression towards greater understanding, improved methodologies, and societal advancement warrants scrutiny. Henceforth, Ecolinguistics, driven by an unwavering commitment to ecological and dialectical epistemologies, harbors profound theoretical and practical implications for concerted endeavors of humanity in tackling the increasingly dire state of global ecological crises.

Conversely, trends in CALL roughly parallel those in other areas of applied linguistics. In contemporary education, it is incumbent upon teachers to assume the responsibility of steering the use of classroom technology toward positive outcomes. To this end, they must deliberate on how to seamlessly integrate technology into daily classroom activities to enhance learning experiences, foster motivation, and align with the personal interests of students [11],[12]. Of particular significance is the imperative to meticulously discern and select apt technologies that effectively fulfill precise educational aims, while concurrently assessing the methodologies employed by educators within their unique teaching contexts [13].

Apropos of the stance elaborated above, this study aimed to elucidate how the developed Ecolinguistic CALL Evaluation scale (ECES) can be implemented, thereby showcasing the extent to which the language users and learners can act as 'social agents' to engage with sociopolitical, cultural and biological tenets of environmental literacy within the mesh of ecological trail. In the current investigation, the ECES valence constructs were delved deeper to be developed by the researcher to assist in procuring information regarding students' environmental literacy, Eco-literacy, and the substance of ecological knowledge to scrutinize the role of natural ecology in shaping solutions to resolve environmental issues in education. Implementing Ecolinguistically CALL-oriented tenets can potentially augment the fundamental environmental literacy of English foreign language (EFL) learners at its core, thereby advancing their overall comprehension of ecological concepts and principles. The constructs played a prominent role since they assisted learners in using their individual skills and competencies to reach an objective. Prior to delving into the methodological design, it is imperative to take a brief retrospective look at the theoretical underpinnings of the study.

Review of the Related Literature

Theoretical Framework

The theoretical framework of this study draws upon and is inspired by several prominent theories in the field. These theories include Bronfenbrenner's Ecological Systems Theory [14], Chaos and Complexity Theory [15], and Van Lier's [16] work. Bronfenbrenner's Ecological Systems Theory provides a conceptual framework that recognizes the dynamic interaction between individuals and their environmental contexts, highlighting the

influence of various systems at different levels (e.g., microsystem, mesosystem, exosystem, macrosystem). Chaos and Complexity Theory emphasizes language learning processes' complex, interconnected nature, acknowledging the non-linear and unpredictable dynamics that emerge in educational contexts. Complex Adaptive Systems Theory further contributes to this framework by emphasizing the adaptive nature of language learning systems, where learners and their Environment co-evolve and mutually influence each other. Non-linear Dynamic Systems Theory acknowledges the dynamic and non-linear nature of language learning, emphasizing the emergence of patterns and behaviors that are not easily predictable or explainable through linear cause-effect relationships. Lastly, Van Lier's work provides insights into the ecological dimensions of language learning, highlighting the reciprocal relationship between learners and their social and cultural contexts. By incorporating these theoretical perspectives, the present study aims to provide a comprehensive understanding of how implementing Ecological Complexity in Environmental Contexts and its subscales can influence the ecological perspectives of EFL learners. In so doing, the study seeks to explore practical and cost-effective evaluation methods for assessing students' Environmental Literacy. In the grand scheme, this theoretical framework provides a rich foundation for investigating the complex and dynamic nature of language learning in environmental contexts and contributes to the broader field of language education and ecological perspectives.

Ecolinguistic Turns
Considering the genesis of Ecolinguistics, it is imperative to examine both ecological and linguistic issues. Nevertheless, Ecolinguistic scholars have proffered numerous pivotal conceptualizations that have been regarded as crucial [17], environmentally significant [18] and ecologically centered [19],[20],[21], epistemologically-oriented [8], as well as scientifically informed [22]. Our investigation concentrated on the environmental facet Steffensen and Fill [10] designated as the critical turn within the Ecolinguistic paradigm, seeking to comprehend the intricacies inherent in the language and the simultaneous endeavors to transcend the confines of academic circles, aiming to heighten awareness regarding the inextricable interplay between linguistic practices and the ecological perils we face. It references the need for a reconceptualization of environmental problems and the nature-culture dichotomy.

Anthropocentrism
The human dimension of Ecolinguistics can be comprehended in terms of the subjects of Ecolinguistic inquiry and the Ecolinguists themselves as researchers and observers. Firstly, human activities have a double-edged role in the ecology of the Earth, with devastating impacts in the Anthropocene era. Secondly, as Halliday [17] recognized, linguists possess the capacity to account for ecological issues and, in so doing, ecologize human behavior.

Environmental Literacy
Environmental education has undergone a diverse and multi-dimensional transformation since the inception of the Tbilisi Conference, which laid the groundwork for environmental literacy (EL), highlighting the process of augmenting individuals' comprehension, consciousness, abilities, and dedication to tackle environmental predicaments [23]. As a Comprehensively instrumental approach, environmental education recognizes the importance of knowledge acquisition, skill

development, and fostering attitudes necessary for responsible environmental stewardship through which Environmental literacy can be developed [24],[25]. EL is often viewed as a continuum ranging from limited awareness and basic knowledge of the Environment to a more thorough understanding of the interactions between social and natural systems, along with the ability to communicate and take action effectively [26]. The continuum also includes deeper levels of environmental literacy, such as the composite framework created by the North American Association for Environmental Education (NAAEE) for the National Environmental Education Guidelines Project, which explicitly incorporated socio-political foundations, the functional knowledge that transcends specific domains, insight into the cultural and social roles of the natural world, and the critical capacity to analyze environmental and societal issues that challenge prevailing norms and ideologies. Linguists operate within the academic and professional spheres to advance the field of linguistics, and they also play a crucial part in maintaining the ecosystem to ensure global well-being in tandem with life sustainability [10].

Of equal significance, a multitude of principles possess the capacity to augment the outcomes pertaining to environmental literacy in online programs. These principles encompass the interconnections between social-ecological domains, the pertinence and applicability of the content, the facilitation of social interactions, role models, the cultivation of autonomy, active engagement of learners, the introduction of challenging tasks, the utilization of diverse modalities, the adoption of a positive framing approach, adequate preparation, the provision of constructive feedback, and the encouragement of reflective practices [27].

Furthermore, a significant corpus of research has been undertaken on environmental knowledge, attitudes, and actions among primary and secondary school populations, higher education, and the general population worldwide. The bulk of the studies utilized quantitative methods for data collection (e.g., [28],[29],[30],[31],[32] to name a few. However, given the predominantly quantitative nature of these studies, it is plausible that more appropriate sampling techniques, context-sensitive research instruments, and advanced statistical analyses could have yielded more robust statistical findings. Most studies reported a positive attitude towards the Environment, with varying levels of environmental knowledge. Nevertheless, a comprehensive inventory of socio-ecological concepts tailored explicitly for the environmental literacy domain has yet to be examined.

Ecological principles and other tenets derived from natural sciences served as fundamental pillars underpinning environmental education and examining ecological challenges. In a similar vein, concepts originating from the social sciences assume a crucial role in this endeavor. Regardless of the volume of ecological knowledge pertinent to a particular issue or the proposed resolution, the intricate mechanics of decision-making unfold within the domain of the social sciences. As Hungerford and Peyton [33] aptly noted, it is in the realm of the social sciences where the pragmatic intricacies of decision-making find their home, transcending the mere influence of ecological knowledge on the problem at hand or its prospective solution.

Given the paramount importance of environmental literacy and the socio-pragmatic domain of environmental literacy, it is imperative to recognize the significance of sociopolitical underpinnings as part of the

cognitive element of environmental literacy [34] to analyze and assess environmental issues and potential technological means.

This evaluation aimed to assess students' application of environmental knowledge and competencies in practical, real-world settings. Such assessments contribute to a holistic comprehension of students' environmental literacy and offer valuable insights for devising educational strategies that foster sustainable behaviors and informed decision-making.

This paper highlights the importance of assessing ECES subscales and the limited availability of data on the current status of ecological perspectives in CALL-oriented settings. Due to the emerging threats of environmental destruction caused by technological breakthroughs and the dearth of a comprehensive outline or inventory of social-ecological concepts tailored explicitly for environmental education, scholars are urged to work with their peer linguists to challenge language in the context of society and ecology and to address environmental problems through education. By delving further into the role of the researcher-observer, it can better be realized how linguists contribute to the field of environmental literacy. Examining the perspectives and experiences of Ecolinguists as they engage with ecological phenomena can enrich our comprehension of the complex relationship between language, humans, and the environment. This deeper exploration elucidates the interconnectedness between anthropocentrism, environmental literacy, and the imperative to cultivate sustainable behaviors and informed decision-making. By integrating these theoretical perspectives and in order to address the gaps in this study, the following research questions were formulated:

Q1. Does implementing the Ecolinguistically CALL-based task affect the ecological perspectives of EFL learners?

Q2. How can evaluating students' EL, particularly their practices in problem identification, analysis, and assessment of possible environmental technology-mediated task responses, be conducted practically and affordably?

Method

Participants

Adopting purposive sampling procedures, several stakeholders (i.e., students and academics) in Iran were surveyed in Iran to yield their responses to some of the administered subscale constructs representing the socio-ecological view of environmental literacy. The participants comprised 30 male and female students of undergraduate English major students and academics. Fifteen learners were assigned to the experimental group and 15 to the control group. The group's ages ranged from 20 to 35 (M=24.87, SD= 3.421). The participating EFL learners took a two-credit audio and visual translation course as part of their bachelor's program. The second segment of the participants comprised six experts from academia. Homogeneous sampling for this subgroup of participants was employed to ensure their homogeneity and interest in the phenomena of interest. They comprised two males specialized in environmental science education, one in mathematics and one doing a degree in engineering, and two female educators in applied linguistics (M=37.50, SD=3.146), including the researcher. The experts were also members of the Society for the Prevention of Cruelty to Animals (S.P.C.) and a Non-Governmental Organization), (NGO), the largest advocacy organization for animal rights and the Environment in Iran, which provided us with qualitative data and exclusive access to mentorship opportunities on several dimensions of biologics to approach our query

from an environmental lens to reach a full-spectrum view.

Instruments

ECES Subscales

As the study is mainly grounded on assumptions and interpretive and methodological approaches of Complex dynamic systems theory (CDST), the ECES, a newly constructed survey-based design instrument developed by Hosseini et al. [35], served as a guiding framework and a cost-effective, reliable instrument in line with these premises. The instrument used in the study was a researcher-made novel questionnaire with 46 questions, of which 11 items were picked to obtain data on students' environmental literacy, Eco-literacy, content aspects, and competency of ecological knowledge. The ECES presented a validated evaluation tool with an acceptable reliability index of .862. to measure ideological, sociological, and biological dimensions with 14 constructs and 46 items defined by the researchers. The ECES was further broken down into distinct subscales honing in on environmental literacy measurement essential to investigate the contribution of natural ecology in CALL-oriented settings.

YouTube Documentary

A CALL-mediated task (an original supplemental CALL environmental literacy material sample) from a YouTube documentary, [36] 'Fighting Fire with Fire: Can Fire Positively Impact an Ecosystem?' contributed as an affordance to direct the teachers' strategies to reach the study's goal. As Ecolinguistics seeks to create linguistic theories that include human beings as an integral part of the larger ecosystems upon which all life depends, it was hoped to demonstrate how language can be applied to resolve pressing ecological issues such as biodiversity loss and environmental injustice.

Interview

As previously stated, a quasi-experimental pretest-posttest research design was utilized, wherein qualitative data collections were conducted to complement and further explicate the findings. Additionally, several methods were utilized to collect qualitative data, including semi-structured interviews, the think-aloud protocol, the co-discovery method, and the self-reporting log method. The semi-structured interviews were conducted both on-site and via telephone for 10-15 minutes, with questions collaboratively constructed by a group of specialists in the field and pilot-tested prior to data collection. (See Appendix A for the list of questions).

The interview protocol was reviewed by a panel of experts and external reviewers to ensure validity and reliability. Inter-rater reliability checks were performed for consistency in coding and analysis. After testing, the logs were collected and analyzed. The interviews focused on key questions of ECES subscale items in English, and participants were provided with printouts of their responses and asked to explain their rationale. The study terminated the interviews when saturation was reached regarding research inquiries, and substantially no more forthcoming information was provided. These methods were chosen for their ability to provide substantial qualitative data while ensuring validity and reliability.

The think-aloud protocol, a standard method, provided a significant amount of qualitative data and was utilized on the grounds of its accessibility. During this process, participants were instructed to articulate their thoughts out loud as they carried out the designated tasks. Their verbal expressions and

corresponding actions were documented for later analysis. Concurrently, the co-discovery method, which involves collaborative work among students on a prescribed task, was also employed. The participants' interactions were observed, and they were encouraged to vocalize their thoughts and interactions during the task, subsequently documenting and analyzing their recorded statements. Moreover, the self-reporting log method, which required participants to maintain a journal to record their actions and thoughts while performing the tasks, was found to be very useful for individuals with limited oral proficiency in English. After testing, the logs were collected, and the written data were examined.

Procedures

In this study, an intervention was employed to examine the impact of an Ecolinguistically CALL-based task and the ECES subscale dimensions on the ecological perspectives of EFL learners. Two intact classes were selected, and a CALL-mediated task from a YouTube documentary was selected within which the biological, sociopolitical, and cultural tenets pertinent to the ECES were identified and elucidated. The task was completed in eight 20-minute sessions, where the learners were also engaged with multiple controlled burn scenarios and probed into the reasons for intentional and prescribed forest wildfires in Iran. The study utilized the five E models (engage, explore, explain, elaborate, and evaluate) to design the supplementary activity and evaluated the effectiveness of the subscales in task fulfillment and their potential to promote environmental literacy in a CALL-specific setting. Prior to the intervention, a pretest was administered to assess participants' ecological perspectives, content aspects, and competency of ecological

knowledge. During the implementation phase and further to quantitative data collection analyses, participants were informed about the fundamental concepts of the environment to foster a robust understanding of environmental literacy domains. Quantitative data obtained from the ECES were analyzed using a paired-sample *t-test* to measure the effectiveness of the intervention.

Additionally, thematic analysis was run through reflective analyses of participants' responses, aiming to gain deeper insights into their ecological perspectives. Moreover, the audio and pdf files of the participants' reflective insights were received via social media platforms and further listened to, analyzed, and transcribed by the researcher to gain a retrospective reflection of their experience. While qualitative work is not designed to provide generalizable statistics regarding trends, it may lay the groundwork for subsequent quantitative research, which we cover in further depth below. Alternatively, this investigation phase aimed to use a CALL-centric task to shed light on the contextualized and interrelated ECES subscales that influence students' environmental literacy, decision-making, and adoption of interventions.

Design

A sequential explanatory mixed methods design was adopted in this study. Subsequent to collecting the quantitative data, the researchers sought to explain findings from the quantitative assessment by conducting and analyzing qualitative data, usually from a smaller number of subjects. As the researchers had access to quantitative instrument design for measuring the constructs of interest, they returned to the participants for the second round of qualitative data collection to synthesize the findings.

Results and Finding

The Quantitative Analysis

The quantitative portion of this study is focused on descriptive-inferential statistics. To compare the experimental group's means, a paired-sample t-test was run on the pretest and posttest of environmental literacy to probe the null hypothesis. Besides, Cronbach's alpha reliability indices were employed for the pretest and posttest of the ecological perspective, and the sample means of the two tests were compared. Later, a descriptive technique was used in qualitative analysis to examine the data obtained through reflective journals and interviews.

In order to investigate the research question, "Does the implementation of the Ecolinguistically CALL-based task influence the ecological perspectives of EFL learners?" and as part of the quantitative evaluation, the essential subscale dimensions in alignment with the environmental literacy facets extracted from the ECES subscales were measured. This online assessment included measures of People, Places, and Environment, Ecolinguistics and Ecojustice behavior, Multimodal Interactive Learning, and Ecological Discourse Analysis. Besides, the effect of the ECES constructs and its subscales was determined on the environmental literacy of EFL learners using semi-structured interviews and a technology-mediated task. The research question was analyzed through a Paired-sample t-test, which

assumes the normality of the data. As represented in Table 1, the ratios of skewness and kurtosis over their respective standard errors were within the ranges of ±1.96; thus, it was concluded that the present data did not show any significant deviation from normality.

Table 1: Cronbach's Alpha Reliability Coefficient for Ecological Perspective

	Cronbach's Alpha	N of Items
Pretest	.892	11
Posttest	.894	11

The Ecological Perspective was measured through 11 items. Table 2 displays the results of Cronbach's alpha reliability coefficients of the pretest and posttest measures of the Ecological Perspective. The two tests enjoyed reliability indices of .892 and .894.

George and Mallery [39] have caution ed that there is no universally accepted criterion for what constitutes an acceptable alpha value. They note that a rule of thumb that can be applied to most situations is that an alpha value of >.9 is excellent, >.8 is good, >.7 is acceptable, >.6 is questionable, >.5 is poor, and <.5 is unacceptable. Based on these criteria, it can be concluded that the pretest and posttest measures of the Ecological Perspective exhibited good reliability indices, with values of at least .80. This indicates that the measures were internally consistent and can be considered reliable for assessing the construct of interest.

Table 2: Normality Indices for Skewness and Kurtosis coefficients of the sample

	N	Skewness		Kurtosis		Ratios	
	Statistic	Statistic	Std. Error	Statistic	Std. Error	Skewness	Kurtosis
Pretest	30	.191	.427	-.941	.833	0.45	-1.13
Posttest	30	-.112	.427	-.769	.833	-0.26	-0.92

A paired-sample t-test was conducted to compare the experimental group's pretest and posttest measures of ecological literacy. The results showed that the posttest mean score (M = 29.43, SD = 8.14) was significantly higher than the pretest (M = 20.47, SD = 7.28). This suggests that the ECES effectively increased participants' ecological literacy. The findings, reported in Table 3, indicated a significant difference between the pretest and posttest scores [t (29) = 14.03, p < .05, r = .983], with a large effect size. As a result, the null hypothesis stating that the intervention had no significant effect on ecological perspectives was rejected.

The Qualitative Analysis

Thematic analysis

The qualitative data from the semi-structured interviews and the practices were assessed, while the student's responses regarding their emergent environmental issues were analyzed. To this end, a set of a priori codes was assigned to segments of texts. Open thematic coding was employed as excerpts were collated for the sake of codification and identification of the overarching themes. (e.g., prescribed fire, wildfire, human-ignited fires, & fire management strategies). Various standards were employed as guides while the data was thematized. First, the nexus between the subscale criteria and Eco-literacy components was identified. Second, we sought how the pertinent ECES subscales contributed to the students' EL in the task practice.

Considering this theoretical stance, the data was coded in two distinct ways: inductively, based on the emerging themes, and deductively, using the study's theoretical underpinnings. For example, when a code from the dataset was relevant to how the fire had contributed to the role of climate and climate-fuel interactions, it was coded as 'Climate-Vegetation Feedback' as related to Environmental knowledge and cognitive element of EL. This coding procedure was done to reach themes across the data. After reviewing the dataset, the themes were aggregated, condensed, and applied to previous and subsequent transcripts. Clusters of interrelated subthemes were identified through axial coding. The generated codes in each cluster were then used to label each cluster. Contextual factors were also coded based on the task, inductively building subthemes (e.g., Political dynamics mismanagement, incentives, local/ tribal politics, biophysical conditions, climate change, and health) as the data was analyzed. The coding approach allowed the researchers to analyze and organize data related to our inquiry, with themes informed by the theoretical literature while identifying emergent themes that may not have been anticipated. Later, the three steps of open coding, axial coding, and labeling were tested for interrater reliability [37]. Therefore, the dataset was reviewed and cross-checked by one of the researchers and an environmental expert [38] to verify the analyses and resolve the existing discrepancies.

Table 3: Paired-sample t-test for Pretest and Posttest of Ecological Perspective

			Paired Differences				
Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		T	df	Sig. (2-tailed)
			Lower	upper			
8.967	.639	7.660	10.273		14.038	29	.000

Then, the researchers got engaged in the discussion of the data and its analysis to (1) gain a better grasp of the analysis procedure; (2) discuss the coding process to refine, cross-reference, and compare the codes and their associated categories; (3) increase the reliability of the analysis through peer discussion and the development of clearly-defined categories; and (4) rule out the possibility that the study did not satisfy its theoretical foundations (i.e., the three components of knowledge, dispositions, and competencies). The studies surrounding EL components were finalized, and the CALL-oriented assignment was completed after the codes and categories were refined, the data was member-checked, and the interviews were integrated and compared to reach a consensus on the emerging themes.

Thematic Analysis Findings

Table 4 presents the data's overarching codes, themes, and sample extracts across the given task regarding knowledge, dispositions, and competency.

Data Sources

Using the criteria in Table 4, the gathered evidence (i.e., interviews, questionnaire items, and the discussions from the watched video) and several interview questions were gleaned. As was explained below, knowledge,

dispositions, and competencies were used in parallel with [40],[41],[42],[26] as coding categories, with each representing an essential part of EL. It was illustrated how environmental particularities and their subcomponents exerted power sources on the students' EL across various stages as we navigated the vodcast, preceding or following the task. Knowledge of how to effectively address environmental issues is what made up the bulk of environmental literacy content domains, knowledge of the physical and ecological systems, the environmental concerns, the sociopolitical domain, and the methods for resolving these issues. Figure 1 illustrates the induced elements of the Environmental literacy framework. Students, educators, and activists revealed their positive and negative perceptions of the subscales in a CALL-mediated task, which functioned as a robust tool shaping their knowledge, dispositions, and competencies.

Insights from the Reflections

Based on the induced data, the participants initially had nebulous views about the efficacy of controlled burns, but after participating in structured and communicative discussions, they valued the task discussions related to environmental issues in a biodiversity context.

Table 4: Codes, Themes, and Sample Extracts

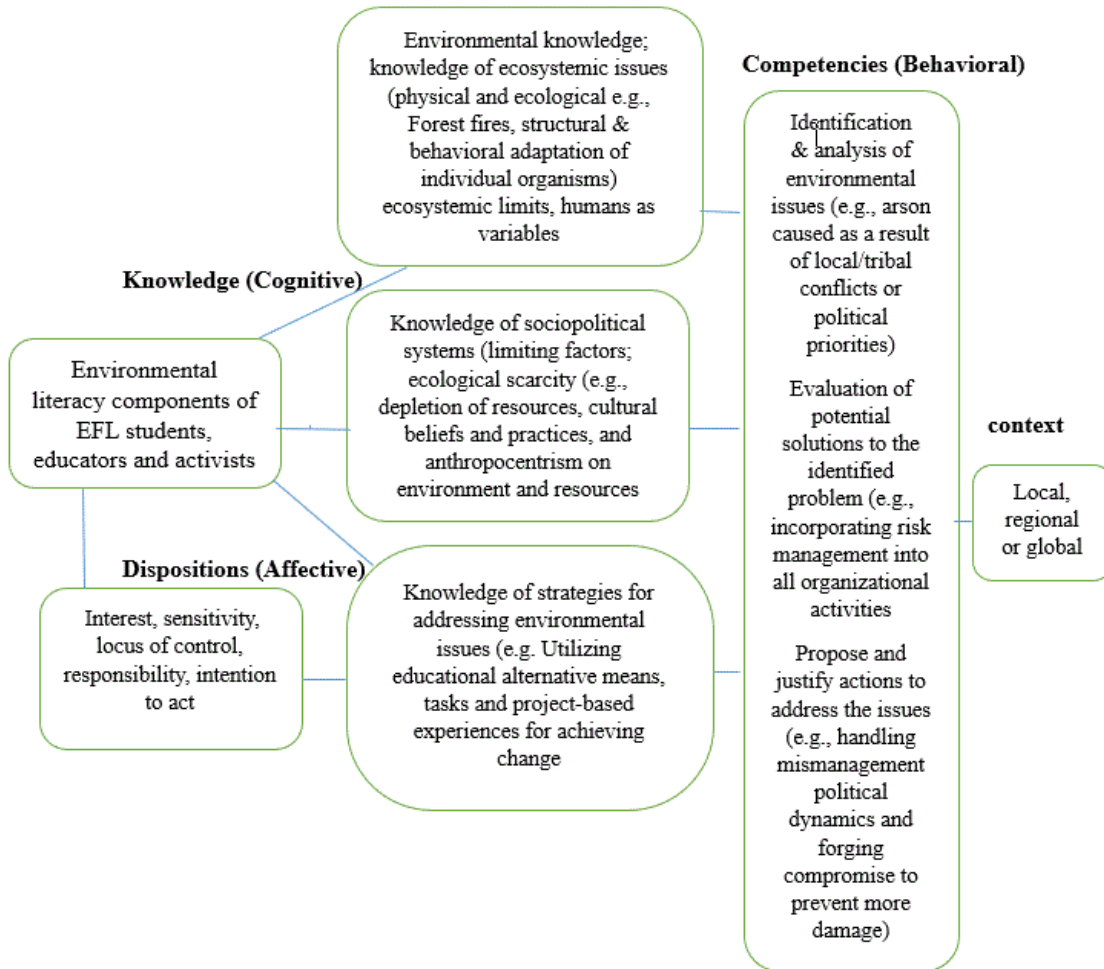| Themes	Subthemes	Examples
Prescribed fire (Humans contribute to altering fire regimes and are impacted by them)	Fire and above-ground biodiversity Fire-vegetation feedbacks	Example: Neda Well, I reckon many species need fire to propagate; most invasive species suffer significant declines in the aftermath of a fire, opening the door for native ones to reclaim their territory. It also leads to the health of plants and can influence their regrowth, reproduction, and germination.
	Fire Effects on below-ground ecology Fire Effects on soil physical, chemical, and biological properties Ecological consequences of temporal and spatial variation in soil properties influenced by fire	Example: Amir Hossein On the bright side, I suppose fire enriches the soil quality by nurturing the recycling of nutrients or slowing the growth of weedy plants that might otherwise smother newly planted seedlings. On the dark side, it leads to erosion and sedimentation, and some animals/plants may unintendedly be killed/injured.
	Climate-vegetation feedbacks The Role of Climate and climate-fuel Interactions	Example: Alireza To my mind, increasing fire activity can reduce ecosystem carbon dioxide storage globally. Fire-induced vegetation change can alter regional climate. Aerosols emitted during fire combustion could also significantly impact regional and global climate.
Wildfire	Burns Climate change and health Mercury and health Mental health	Example Kimia: Wildfires have a pernicious effect on mental health and psychosocial well-being. PM2. 5-minute toxic particle matter is found in high concentrations in the smoke, which may even be absorbed through the epidermis. Particles breathed go far into the lung tissue. Strokes, asthma, and heart attacks result from any of them. The current research also confirms that tiny particles lodge easily into the brain.
Human-Ignited fires	Local/Tribal	Example: Mohsen I think most forest fires are human-ignited. Either unintentionally or deliberately (Tribal conflicts). The sun is concentrated on a dry fuel patch by various sources, including cigarettes, campfires, burning trash, military ammunition, and even a discarded glass bottle laid by humans.
Fire management strategies	Political Dynamics Mismanagement	Example: Afsoon My view on the matter is that some of the root reasons for the biased decision-making amid emergency response typically involve general decision biases, leadership and team dynamics, lack of equipment, and variations in perspectives between top executives and incident management teams, leading collectively to severe damage to the Environment.

Fig. 1: Induced Elements of Environmental Literacy Framework

The students expressed their perceptions about the causes of human-caused wildfires, fire management strategies, and the role of risk management in wildfire response, underscoring the importance of balancing different variables and developing risk-informed, strategic innovations to aid decision-makers during wildfire event response. To their knowledge, effective risk management requires an analytical and preventative strategy considering contextual variability, uncertainty, and the best available data for decision-making.

The received data provided a comprehensive analysis of the impact of fire on biodiversity, ecology, and climate change. One of the key themes was prescribed fire, which explored how human contributions to altering fire regimes impact biodiversity and vegetation feedback. While fire can benefit plant health and open the door for native species to reclaim their territory, it can also lead to unintended animal/plant deaths, injuries, and erosion. Another important subtheme was the impact of fire on below-ground ecology and soil properties, where the fire could enrich soil quality by nurturing nutrient recycling but also lead to sedimentation and the slowing of plant growth. Climate-vegetation feedback was another critical subtheme, with Alireza, a participant, suggesting that increasing fire activity can reduce ecosystem carbon dioxide storage globally and alter regional climate.

Additionally, wildfires have a pernicious effect on mental health and psychosocial well-being due to high concentrations of particulate matter (PM2). Five-minute toxic particle matter

in the smoke can lead to strokes, asthma, and heart attacks. Moreover, the presented data examined human-ignited fires and their impact on biodiversity, ecology, and climate change, with Mohsen suggesting that most forest fires are human-ignited, unintentionally or deliberately, due to tribal conflicts. Finally, the data discussed fire management strategies and the political dynamics involved in mismanagement, where biased decision-making during emergency response can lead to severe damage to the environment due to general decision biases, leadership and team dynamics, lack of equipment, and variations in perspectives between top executives and incident management teams. Overall, the analysis underscored the complexity and multifaceted nature of fire's impact on the environment, with both positive and negative consequences. It highlighted the importance of understanding the ecological consequences of fire and the need for effective fire management strategies to minimize its adverse effects. Furthermore, the data emphasized the critical role of human behavior in shaping fire regimes

and the need for greater awareness and responsibility to mitigate its impact on biodiversity, ecology, and climate change.

Based on the induced data of the second part of the study drawn from the thematic analysis [43] and to address the second research question of the EFL students, educators, and activists in the identification of issues and strategies in an environmental scenario within the CALL-oriented setting, four overarching themes emerged: (1) There is a limit to how far individual actions may go toward solving environmental issues, as environmental issues are intricate. 2) The preconceived notions about sociopolitical and cultural beliefs that create roadblocks to implementing systemic changes in environments and resources at the local, regional, and global levels. 3) The role of digital technology in fostering environmental literacy, and finally, 4) Challenging Anthropocentrism through Multimedia Resources. Table 5 summarizes the two overarching themes and example extracts induced from the participants.

Table 5: Overarching themes addressing the functional, cultural, and critical perceptions of participants toward environmental literacy

Themes	Description	Level	Example
Limitations of Individual Actions	Environmental issues are complex and multifaceted, and while individual actions can make a difference, they have limitations in terms of solving more significant environmental problems.	Functional	Original text: Azadeh: Collectively speaking, human assemblies, or governments, are now engaged in activities that will impact the interconnected web of life that we refer to as the "environment." As politics influence the disposition of governments and how those governments may and will affect the Environment, it is essential for all human beings in the world to voluntarily persuade governments to secure a future that includes a healthy environment responsibly.
Sociopolitical and Cultural Roadblocks	Preconceived notions about social, political,	Cultural and Critical	Original text: Saman: Personally, I do not feel very optimistic as I think these efforts and

Themes	Description	Level	Example
	and cultural beliefs can act as barriers to implementing systemic changes in environments and resources at the local, regional, and global levels.		footprints can hardly amount to a drop in the ocean. It is hard to make a giant impact without top-down systemic changes. The time for action is dire. We are deep into an irreversible trend of environmental disasters, and the officials just blamed the collective irreversible changes, and by this, they have concluded that the issue is already closed to debate. For them, including activism and support in the curriculum is futile and unnecessary.
Challenging Anthropocentrism through Multimedia Resources	The negative impact of anthropocentrism on the environment, including the devaluation and demeaning of nature and the belief in human domination over creation.	Critical	Original text: Amin: I feel our Environment is an intricate web. Nothing exists in a vacuum. Yet, people behave as if our actions have no consequences and are not separated from the web of life. Until humanity can curb its numbers and give up anthropocentrism and its negative impacts on the Environment, we will have environmental problems. Therefore, using digital platforms could widen the reach and scope of teaching and Learning.
The role of digital technology in fostering environmental literacy.	Raising ecological awareness and encouraging action towards environmental sustainability.	Functional	Original text: Banafshe: From its onset, social media has served as a platform for the EFL teaching community, activists, and every layman to raise their voices and concerns on environmental issues over and above the hazards of anthropocentrism on the social landscape. Images, videos, games, memes, and campaign commercials detailing simple steps that anybody Can do to make the world a cleaner and greener place is multimedia sources. Videos showing the potential disaster that might befall our planet if environmental deterioration continues have raised consciousness and galvanized a desire for action. In a nutshell, multimedia resources undeniably play a pivotal role in elevating global ecological awareness for the EFL teaching community.

Collectively speaking, analysis of the participants' reflections revealed that students, teachers, and activists were of varying EL levels. As they explained their thought processes in issue identification, teacher participants with more experience provided more nuanced and intricate explanations. There is also a more powerful combination of social and ecological concerns. When comparing and contrasting problems, it was figured out that the contextual view of EL proposed by Stables [26] (functional, cultural, and critical levels) played a role. Critical-level individuals were grappling with the social repercussions of environmental issues.

The concept of socio-ecological systems and disposition was taken for granted at the functional level but deemed insufficient to promote necessary action in the contextual view of EL. Students were inspired to engage in the cultural knowledge practices and behaviors of experts by being exposed to and learning from them. Peer effects on identification may be at play among activists and environmental students because 1) they are more likely to hold a degree in environmental studies and 2) they are more likely to work in settings with a social cohort that is environmentally conscious or engaged.

All else being equal, it was assumed that students' environmental literacy could be appraised practically and affordably by developing a digital application that provides resources and guidance to users on environmental issues and concerns. This may help students get hands-on experience with coding and building an application that can aid others in learning about and taking action toward environmental issues. Students could create digital presentations or infographics on environmental topics of their choice, thus helping students apply their knowledge of technology and environmental issues creatively and positively. Additionally, digital communication gizmos, such as social media and online forums and videos, augmented reality simulations for environmental education, and gamification can be used to assess students' understanding of environmental issues and their involvement in related issues and discussions.

Discussion

Inspired by Bronfenbrenner's Ecological Systems Theory [14], Chaos and Complexity Theory [15], and Van Lier's [16], this paper has explored the implementation of the Ecolinguistic CALL Evaluation Scale (ECES) from three angles: a quantitative analysis of the key subscale dimensions in alignment with the environmental literacy facets pulled from the ECES; an examination of the effect of implementing the ECES constructs and its subscales on the environmental literacy of EFL learners and assessment of practices in addressing the participants' collaborative investigation and identification of issues and strategies in promoting environmental literacy. The qualitative data also illuminated the interconnection of ECES subscales and the ecological perspectives of participants. The results of the analyses of the participants' reflections and implementation of the constructs of ECES subscales indicated a positive, significant effect on the ecological perspectives of participants.

As to our research question in implementing the constructs of ECES and its subscales to affect the ecological perspectives of EFL learners and based on the conceptual framework of environmental literacy formerly outlined, the concepts through subscales and reflective practices were represented to collect evidence of students' sociopolitical, cultural and environmental knowledge. The four primary content domains comprising the framework were the knowledge of physical and ecological systems, environmental issues, sociopolitical knowledge, and strategies for addressing environmental issues. Notably, concepts of the subscales were taken from the social sciences, including anthropology, sociology, political science, and technology embedded within the CALL domain.

At first glance, the study seemed to overemphasize the role of environmental issues of concern and Ecolinguistics in the current ecological meaning of the Physical

Environment. This sophomoric view somewhat contradicted the pivotal position accredited by Van Lier [16] to the role of teacher and students' agency and the Environment in a sense encompassing all the physical, social, technological, and symbolic affordances that can steer a classroom debate to a fruitful end. The proposed stance also aligns favorably well with the words of Garrett [11], Warschauer, and Cook [12] for teachers in directing classroom activities with technology incorporation, thus making learning more rooted in students' interests.

On second thought, the distinction provides different perspectives on Language's Environment: Each provides a figure-ground constellation that emphasizes one ecological dimension without discounting the other two. This is in good agreement with the natural ecology view and concurs well with Halliday's perspective and the notion of the transformative effect of language on ecology [44], the complementarity of the field of applied linguistics and its contribution to maintaining nature for life sustainability and global well-being further corroborated by Alexander and Stibbe [10].

Based on participants' reflections, one way the teacher employed to practically and affordably evaluate students' EL was to have students assess and develop ideas of how concerning resources and guidance could assist with environmental concerns. This could help students get hands-on experience with coding and building a set of themes that could aid others in learning about and taking action toward environmental issues. Some even created digital presentations or infographics on environmental topics of their choice. This helped students apply their knowledge of technology and environmental issues creatively

and positively. Additionally, the students put forward digital communication tools such as social media and online forums to assess their understanding of environmental issues and their involvement in related issues and discussions. This view is in good agreement with the words of Halliday [17] that through digital technology, linguists can bring ecological issues into account, and, in so doing, researchers can ecologize human behavior.

Regarding the interconnection between environmental literacy, digital affordances, and anthropocentrism, it can be argued that among the crucial constructs of the subscales and the online social platforms that reflect the community's power to construct every individual's life and mind, such as beliefs, ethics, and political awareness and the precepts further proposed by [45] of goal-oriented of general education are the human actions having both positive and negative repercussions on the Environment. Environmental literacy veritably sets the parameter in recognizing and perceiving the relative health of environmental systems and taking appropriate action to preserve, restore, and enhance the health of those systems. Based on Roth [45] and the results drawn from the environmental experts in this study, formal environmental education was substantiated to draw its strength mainly from several macro issues, including the interrelationships between natural and social systems, the unity of humankind with nature, contextual and cultural values embedded within the affordance of technology, the making of choices and the developmental learning throughout the human life cycle. We purportedly proved that improving an individual's environmental knowledge results in more favorable attitudes towards the Environment [46], which in turn

may assist in developing more responsible environmental behavior (however, the educational and communicative link between cognitive and affective components and the overall behavior follows a complex non-linear pattern). In alignment with earlier findings regarding environmental knowledge not being a sole precursor, we figured out in a comparable vein that it can act as a linchpin to promote and lead to environmentally responsible behavior among individuals.

Concerning the moral and ethical standpoints, the targeted participants were examined on their reflective insights on one of the subscale issues related to anthropocentrism and eco-centric lines of consciousness. As this model of consciousness is based on the assertion that humans should not be esteemed as the core element of the universe but a part of the natural Environment, eco-centric consciousness was found to be associated correspondingly with the issues of diversity and harmony of Man's coexistence in a natural environment rather than of intellectual domination and global convenience. This view lent support to 'Ecologization' in humanitarian sciences being sparked by the need to investigate the social and cultural life of peoples through the paradigm of their Environment [47],[48],[49], as educators have time and again transformed far beyond the biological sense of ecology and integrated this notion with humanitarian task implementation and bore a broad vision on their understanding of the universe, human nature, agents' role, and education's significance. This is partly due to language education, which is morally and ethically concerned with issues such as the impact of ecological relations on technology, language development, identity formation, human well-being, and life sustainability.

Axiologically speaking, the significance of protecting natural environments ran counter to the anthropocentric worldview, as quoted by one of the participants of this study. Similar views lead many to believe that ecological ethics principles are much more crucial to the question of human existence than anthropocentric notions of worth.

Conclusions

In conclusion, as an interdisciplinary study, this investigation examined the effects of the treatment implemented via the ECES subscale constructs on the environmental literacy of EFL learners. Results revealed that EFL students' environmental attitudes, reflective insights, and perceptions markedly improved. The ECES was enlarged as the study attempted to represent how the ecological model of language learning could provide a theoretical lens through which students' CALL practices are explored to encourage learner agency. Given the role of technology in bringing diversity to the classroom as leverage to draw out learners' agency in improving EL, the analysis centered on a technology-mediated task that illustrated the interaction between and among the affordance of technology, the teacher participant's pedagogical considerations, and their goal of encouraging learner agency in addressing and promoting environmental literacy. These three strands weaved together to provide a consummate picture of the setting and a springboard for future research on EL in the classroom.

The implications of this study for both the pedagogical and academic domains are significant. Firstly, implementing the approach examined in this study has the potential to improve the environmental literacy of EFL

learners significantly. Secondly, the holistic view of language learning and development espoused by ecological linguistics has the potential to have a profound and beneficial impact on the advancement of linguistics, pedagogy, education, and other disciplines. This approach considers all aspects of the Environment and situation of the learner, in contrast to traditional approaches to CALL evaluation that focus solely on the language per se. Implementing both of these approaches could provide learners with valuable insights into their understanding of environmental literacy practices, especially in our ever-changing and technology-driven world. However, further research is needed to explore teachers' pedagogical choices based on the perceived technological affordances and interactions between teacher and student agency mediated by these affordances in the classroom ecology. As multiple contributing factors may affect the results of this kind of study, it is essential to control the variables and carefully account for any confounding factors. Future research should also study a more extensive sample composed of other stakeholders and transdisciplinary domains. This would necessitate novel research that seeks to fill in knowledge gaps when seen through the lens of heuristic and transdisciplinary frameworks. The study encourages teachers to adopt more student-centered, transformational, and experiential pedagogical stances with regard to environmental literacy in the classroom. It is also necessary to ensure that the technological resources used in CALL are accessible to all learners and that technology-based learning resources and materials are appropriate for the diverse linguistic identities of learners and their communities, promoting equity and inclusivity in CALL contexts.

A host of potential limitations need to be considered in this study. To begin with, as to the multifaceted concepts existing within the ECES subscales, the effects of the scores of other remaining constructs were overlooked. Second, although the reflective insights of the participants were investigated, the examination of their EL was not put into action as it was beyond the scope of this study. This study's results and applied approaches have conceivably been promising and have made notable strides in augmenting our comprehension of the EL at hand, providing valuable insights that have contributed to a deeper and more nuanced understanding of the phenomenon under investigation. However, some course of action still needs to be taken. The best-case scenario occurs when such efforts will have value in supporting more effective decision-making and augmenting our understanding of systemic change initiatives in the context of curriculum design and policy.

Recommendations of this study may include understanding the sociolinguistics of language learners and their communities, including their language variation, use, and attitudes, and the broader social elements that may influence language learning. Additionally, it is essential to consider the affordances of the tools, their support for language learning, and how they may align with ecological and socio-pragmatic perspectives.

Overall, the fact that language comprises a vast array of concepts and permeates nearly every aspect of human existence makes the application of Ecolinguistic analysis and principles pervasive. This implies that human interaction can be the subject of diverse hypotheses. Thus, learners can develop environmental literacy as the first stage toward a more comprehensive understanding of

interaction with ecological aspects, namely to develop an organic understanding of the world and participation in environmental action.

Last but not least, the findings of this research will enable and recommend the adoption of an eco-dimensional approach that balances a number of issues relating to the instability of the human Environment and the expansion of the ecosystem's capabilities through the incorporation of technical concepts, methods, and techniques of linguistic analysis. This approach grants universal instruments for the implantation of humanitarian tasks through CALL. It provides valuable insights that contribute to a deeper and more nuanced understanding of environmental literacy, supporting effective decision-making in augmenting our understanding of systemic change initiatives in the context of curriculum design and policy.

Authors' Contribution

The first author handled data acquisition, did the write-up, and provided administrative, technical, and material support. The first and corresponding authors were involved in data analysis and interpretation. The manuscript drafting was collaborative, with all authors contributing their expertise. Each author was crucial in reviewing and revising the manuscript for scholarly integrity. The supervisory committee provided valuable guidance throughout the research process.

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Conflicts of Interest

We have no conflicts of interest to disclose, and there has been no financial support for this novel work that could have influenced its outcome.

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