

Research on the Interdisciplinary Teaching Model Combining Sustainable Development and English Education

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ABSTRACT Preparing graduates for emerging engineering disciplines requires educational models that simultaneously cultivate domain knowledge, interdisciplinary collaboration, and effective international communication. In fields such as electromagnetic engineering, advanced materials, and intelligent manufacturing, the ability to address sustainability challenges through project-oriented problem solving has become increasingly important. This study develops and quantitatively evaluates an interdisciplinary project-based learning (PBL) framework that integrates sustainable development concepts into university English education through an authentic textile lifecycle scenario. Centered on Sustainable Development Goal 12, the proposed model engages students in investigating textile resource utilization, waste reduction, and circular economy practices while employing English as the primary medium for research, collaboration, and technical communication. A quasi-experimental pretest–posttest design involving 120 undergraduate students was implemented to compare the proposed framework with conventional instruction. After a 16-week intervention, the experimental group demonstrated statistically significant improvements in both sustainability awareness and English proficiency, with large effect sizes observed in covariance analysis. The findings indicate that embedding real-world engineering challenges into language education effectively promotes systems thinking, interdisciplinary problem-solving, and professional communication skills. Beyond textile sustainability education, the proposed framework provides a transferable pedagogical paradigm for cultivating globally oriented engineering competencies relevant to multidisciplinary fields involving advanced materials, intelligent sensing, and electromagnetic technologies.

INDEX TERMS project-based learning, sustainable development, engineering education, interdisciplinary learning, systems thinking

I. INTRODUCTION

THE adoption of the United Nations 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs) represents a universal framework for addressing the world's most pressing environmental, social, and economic challenges [1,2]. Central to this agenda is the recognition that education is a critical enabler for achieving these goals. This recognition has given rise to the paradigm of Education for Sustainable Development (ESD), an interdisciplinary educational approach aiming to equip learners with the knowledge, skills, values, and attitudes necessary to contribute to a more sustainable and equitable future [3]. ESD transcends the mere transmission of environmental content; it is a transformative pedagogy that fosters competencies such as critical thinking, systems analysis, collaborative problem-solving, and a sense of responsibility as global citizens. Therefore, integrating ESD principles throughout the entire educational system is not merely desirable but imperative for long-term global well-

being.

Within this global educational shift, the field of English language teaching (ELT) occupies a unique and strategic position. As the predominant global lingua franca, English serves as the primary medium for international discourse, collaboration, and knowledge dissemination on sustainability issues ranging from climate science to social justice [4,5]. This reality transforms the English language classroom from a site of purely linguistic instruction into a potent platform for ESD implementation. Integrating sustainability themes into ELT curricula offers a dual benefit: it provides a rich, authentic, and intrinsically motivating context for language learning, while simultaneously leveraging the global reach of English to cultivate environmental awareness and inspire action across cultures [5]. By engaging with complex, real-world problems such as biodiversity loss or responsible consumption, students are prompted to develop not only their language skills but also higher-order cognitive abilities, thereby making the learning process more relevant

and impactful. This integration fosters a symbiotic relationship in which the urgency of sustainability challenges drives meaningful language use, and enhanced language proficiency empowers students to participate in global sustainability conversations.

Despite a growing scholarly consensus on the value of integrating ESD and ELT, a significant gap persists between theory and validated practice. Much of the existing literature consists of theoretical arguments, case studies, or systematic reviews that highlight prevailing trends and challenges but fall short of providing rigorous empirical evidence for specific pedagogical models [6,7]. There is a noted scarcity of quantitative, experimental, or quasi-experimental studies that systematically evaluate the effectiveness of replicable teaching frameworks within higher education settings [8,9]. The field requires robust research that moves beyond advocating for what should be done to demonstrating how it can be done effectively and measuring its dual impact on both language acquisition and sustainability competencies. Without such evidence, curriculum designers and educators lack validated models to guide their efforts, potentially hindering the widespread and effective implementation of ESD in ELT.

This study aims to address this critical research gap by designing, implementing, and quantitatively evaluating an interdisciplinary teaching model that integrates SDGs into a university-level English course through a project-based learning (PBL) framework. The research is guided by two primary questions: (1) Does the SDG-PBL model lead to a statistically significant improvement in students' English language proficiency compared to traditional instruction? (2) Does the SDG-PBL model lead to a statistically significant improvement in students' sustainability awareness compared to traditional instruction? By providing empirical data on a specific, structured intervention, this study seeks to offer a scientifically grounded and replicable model for educators and institutions committed to advancing the goals of both quality language education and sustainable development.

II. LITERATURE REVIEW

A. PRINCIPLES OF EDUCATION FOR SUSTAINABLE DEVELOPMENT (ESD)

ESD as defined by UNESCO is a lifelong learning process and an integral part of quality education that empowers learners to make informed decisions and take individual and collective action to address interconnected global challenges [10,11]. ESD is fundamentally an interdisciplinary approach that seeks to balance economic, social, and environmental considerations in the pursuit of a sustainable future. The core objective of ESD is to cultivate a set of key cross-cutting competencies that enable individuals to act as agents of change. These competencies include systems thinking (the ability to recognize and understand relationships), anticipatory competence (the ability to understand and evaluate multiple futures), normative competence (the ability to understand and reflect on the norms and values

that underlie one's actions), and strategic competence (the ability to collectively develop and implement innovative actions that further sustainability) [5]. ESD is explicitly linked to the UN SDGs, serving as a vital enabler for all 17 goals and being the central focus of SDG Target 4.7, which calls for ensuring all learners acquire the knowledge and skills needed to promote sustainable development [5,12]. Therefore, ESD is not an "add-on" to the curriculum but a transformative lens through which to reorient the entire educational enterprise.

B. THE INTERSECTION OF ENGLISH LANGUAGE TEACHING (ELT) AND EDUCATION FOR SUSTAINABLE DEVELOPMENT (ESD)

The integration of ESD into ELT is both natural and powerful. As a global language, English provides the communicative tools necessary to engage in international dialogue and collaboration on sustainability issues. The ELT classroom, with its inherent flexibility in teaching materials and methods, offers an ideal environment for fostering the critical thinking and action competence central to ESD [13,14]. Incorporating sustainability-related content—such as climate change, gender equality, or sustainable cities—provides authentic, meaningful, and engaging material for language practice. This approach enhances the relevance of language learning, shifting the focus from decontextualized grammar drills to using language for real-world communicative purposes [15,16]. Research indicates that this integration fosters not only linguistic and critical thinking competencies but also social and emotional learning competencies, such as empathy, intercultural communication, and a sense of global citizenship. By framing language lessons as platforms for exploring significant global challenges, educators can transform students from passive language learners into active, informed global citizens equipped with the communication skills necessary to contribute to a more sustainable world [17,18].

C. PROJECT-BASED LEARNING (PBL) AS AN OPTIMAL FRAMEWORK

To effectively operationalize the integration of ESD and ELT, a pedagogical framework is needed that is inherently interdisciplinary, student-centered, and action-oriented. PBL emerges as a particularly suitable methodology. PBL is an inquiry-driven teaching method in which students gain knowledge and skills by working for an extended period to investigate and respond to an authentic, engaging, and complex question, problem, or challenge [19]. This approach moves beyond knowledge acquisition to focus on competency development, enabling real-world action. The "Gold Standard PBL" model provides a robust framework for designing effective projects, built upon seven essential design elements. These elements align seamlessly with the goals of ESD and the communicative nature of ELT [20,21]. First, a challenging problem or question grounds the project in a real-world issue, which can be directly derived from

one of the UN SDGs. Second, sustained inquiry requires students to engage in a rigorous, extended process of asking questions, finding resources, and applying information, which naturally involves extensive use of English for research and analysis. Third, authenticity connects the project to students' personal lives and the broader community, making the work meaningful and relevant. Fourth, student voice and choice empower learners to make decisions about the project, fostering autonomy and ownership. Fifth, reflection is integrated throughout the project, prompting students to think about what they are learning, how they are learning, and why it matters. Sixth, critique and revision involve students giving and receiving feedback to improve their process and products, which is a critical component of both academic and professional communication. Finally, a public product requires students to share their work with an audience beyond the classroom, creating a powerful motivation for high-quality work and providing an authentic context for formal English communication, such as presentations or written reports [20,21].

The structure of PBL provides a vehicle for shifting students from a state of passive awareness to one of "action competence." While many students express concern about sustainability, they often lack the skills or sense of agency to address these issues effectively [22]. The PBL framework, particularly its emphasis on creating a tangible public product to address a challenging problem, compels students to move beyond simply learning about an issue [23]. It requires them to synthesize knowledge, collaborate with peers, solve complex problems, and communicate their proposed solutions persuasively in English. This process directly cultivates the action-oriented competencies that are the ultimate goal of ESD, transforming the ELT classroom into a dynamic workshop for developing and articulating solutions to global challenges.

III. RESEARCH DESIGN AND METHODOLOGY

A. RESEARCH DESIGN

This study employed a quasi-experimental, pretest-posttest non-equivalent control group design to evaluate the effectiveness of the SDG-PBL teaching model. This design was selected as the most appropriate and feasible approach for a real-world educational setting. In such contexts, the true random assignment of students to different classes is often impractical, as it can disrupt established schedules and class cohesion. The quasi-experimental design mimics the conditions of a true experiment by including a comparison group and utilizing statistical techniques to control for pre-existing differences between the groups. By using pretest scores as a covariate in the analysis, this design allows for a more rigorous assessment of the intervention's causal effect than a simple pre-post comparison without a control group, thereby enhancing the study's internal validity.

B. PARTICIPANTS AND SETTING

The participants in this study were 120 second-year undergraduate students from a comprehensive university in China. The students were non-English majors enrolled in a compulsory college English course. Two intact classes, each with 60 students, were selected for the study. One class was assigned as the experimental group, which received the SDG-PBL intervention, and the other served as the control group, which followed the traditional curriculum. The sample consisted of 68 female (56.7%) and 52 male (43.3%) students, with an average age of 19.4 years ($SD = 0.7$). An independent samples t-test conducted on the pretest scores for both English proficiency and sustainability awareness confirmed that there were no statistically significant differences between the two groups at the outset of the study ($p > 0.05$), establishing a comparable baseline for the intervention.

C. THE INTERVENTION: A SUSTAINABLE DEVELOPMENT GOAL-PROJECT-BASED LEARNING (SDG-PBL) MODEL

The intervention was conducted over a 16-week academic semester. To control for potential teacher effects, both groups were taught by the same instructor. Both groups received English instruction for the same duration (4 hours per week), but the pedagogical approach and content differed significantly. The experimental group participated in a comprehensive PBL project centered on SDG 12: Responsible Consumption and Production, with a specific focus on the authentic and locally relevant issue of "Fast Fashion and Textile Waste on Campus." The project was meticulously structured according to the Gold Standard PBL elements:

Weeks 1–2 (Challenging Problem and Authenticity): The project was launched with the driving question: "How can our university community reduce its textile waste and promote sustainable fashion choices?" This question was designed to be open-ended, engaging, and directly relevant to the students' own experiences and environment.

Weeks 3–8 (Sustained Inquiry): Students were organized into small groups and embarked on a sustained inquiry phase. To ensure comprehensive engagement with the multiple facets of SDG 12, the instructor provided a guiding framework structured around the entire textile lifecycle. This prompted students to research not only post-consumer waste but also crucial upstream issues. Their inquiry included investigating the sustainable management of natural resources such as water in cotton farming, the environmental impact of dyes in responsible production, and the social implications within global supply chains. Alongside this research, they designed and administered surveys in English to analyze the consumption habits and attitudes of their peers on campus. This structured approach ensured students grappled with the interconnected sub-targets of SDG 12, from resource use to waste generation, providing a rich context for language learning.

Weeks 9–12 (Student Voice, Critique, and Revision): Based on their research, each group was given the autonomy to develop a specific, actionable solution. Proposed projects included creating a business plan for a campus thrift shop, designing a series of clothing repair workshops, or developing a social media awareness campaign. Groups prepared and delivered initial presentations of their ideas in English, receiving structured feedback from both the instructor and their peers, which they then used to revise and refine their proposals.

Weeks 13–15 (Reflection and Public Product): Groups focused on creating their final public product: a formal, well-structured proposal written in academic English, complete with a budget, implementation timeline, and projected impact. They also prepared a persuasive oral presentation to accompany their written proposal. Regular reflection activities, such as journaling and group discussions, were integrated to encourage metacognition about their learning process and the development of their project.

Week 16 (Public Product Presentation): In the final week, groups presented their proposals to an authentic public audience. The panel included a university administrator from the campus logistics department, a representative from the student union, and a faculty member from the environmental science department. This culminating event provided a high-stakes, meaningful context for students to use their English communication skills for a real-world purpose. The control group received instruction based on a standard university English curriculum during the same 16-week period, structured around a widely used English textbook. The course was organized into thematic units (e.g., global travel, technology trends), with each unit typically spanning two weeks. On average, a unit dedicated approximately four hours to explicit instruction on theme-related vocabulary and grammar points, and four hours to communicative practice activities. These activities included textbook-based pair work, structured group discussions on unit topics, and short writing assignments. While this curriculum provided regular practice in all four language skills and incorporated communicative tasks, these tasks were self-contained within each discrete thematic unit. The key difference from the experimental group was the absence of a single, overarching, long-term project that required sustained inquiry and the application of language skills to solve an authentic, complex problem.

D. DATA COLLECTION INSTRUMENTS

Two instruments were used to collect quantitative data at the beginning (pretest) and end (posttest) of the 16-week intervention:

English Proficiency Test: To measure students' academic English proficiency, a comprehensive test was developed by a panel of three experienced English language instructors. The test was designed to mirror the format, item types, and difficulty level of the College English Test Band 4 (CET-4), a nationally recognized standardized test in China that

serves as a relevant benchmark for this student population. To ensure content validity, the test items and proficiency descriptors were reviewed and confirmed by two additional senior faculty members. To ensure scoring reliability for the subjective writing and translation sections, all scripts were independently marked by two trained raters who were blind to the students' group assignments. The inter-rater correlation coefficient was calculated to be 0.91, indicating a high degree of consistency. Any scoring discrepancies were resolved through discussion with a third senior rater. Two parallel versions of the test, confirmed to be of equivalent difficulty by the panel, were created and administered as the pretest and posttest to avoid practice effects.

Sustainability Awareness Questionnaire (SAQ): Students' sustainability awareness was measured using a questionnaire adapted from validated instruments used in higher education research. The SAQ consisted of 20 items rated on a 5-point Likert scale, from 1 (Strongly Disagree) to 5 (Strongly Agree). The questionnaire was designed to assess three key dimensions of sustainability literacy: knowledge (e.g., "I can explain the concept of a circular economy"), attitudes (e.g., "It is important for me to purchase products from socially responsible companies"), and self-reported behaviors (e.g., "In the past three months, I have repaired an item of clothing instead of discarding it"). To ensure the SAQ's cultural and linguistic appropriateness, a multi-stage adaptation process was employed. Following an initial translation into Chinese and an independent back-translation, a bilingual expert panel—comprising two English language educators and one environmental science professor—reviewed the instrument. This panel assessed the items for conceptual equivalence, cultural relevance, and clarity. After minor revisions based on the panel's feedback, the Chinese version of the SAQ was pilot-tested with 20 non-participating students to confirm that the items were clear and unambiguous in the local context. The internal consistency of the SAQ was found to be high, with a Cronbach's alpha coefficient of 0.89 for the pretest administration.

E. DATA ANALYSIS

All quantitative data were analyzed using SPSS (Version 28.0). First, descriptive statistics, including means and standard deviations, were calculated for all pretest and posttest scores for both the experimental and control groups. The primary statistical method used to test the research hypotheses was analysis of covariance (ANCOVA). Two separate ANCOVA tests were conducted, one for the English proficiency posttest scores and one for the sustainability awareness posttest scores. In each analysis, the group (experimental vs. control) was the independent variable, the respective posttest score was the dependent variable, and the corresponding pretest score was included as a covariate. This method allowed for the statistical control of any initial differences between the groups, thereby providing a more accurate estimate of the intervention's effect. Prior to conducting the main analyses, the data were screened to ensure the

assumptions for ANCOVA were met. Levene's test indicated homogeneity of variances, and a non-significant interaction between the covariate (pretest score) and the independent variable (group) confirmed the critical assumption of homogeneity of regression slopes for both dependent variables ($p > 0.05$). A significance level of $p < 0.05$ was established for all statistical tests.

IV. RESULTS

This section presents the quantitative findings of the study. The analysis focuses on comparing the performance of the experimental group (SDG-PBL) and the control group (traditional instruction) on measures of English proficiency and sustainability awareness following the 16-week intervention.

Descriptive statistics for the pretest and posttest scores for both groups are presented in Table 1. At the pretest stage, the two groups exhibited very similar mean scores on both English proficiency and sustainability awareness. Following the intervention, the experimental group showed a marked increase in the mean scores for both variables, while the control group demonstrated only minimal gains.

TABLE 1. Descriptive Statistics of Pretest and Posttest Scores for English Proficiency and Sustainability Awareness

Variable	Group	N	Pretest Mean (SD)	Posttest Mean (SD)
English Proficiency (out of 710)	Experimental	60	410.50 (65.21)	465.80 (68.15)
	Control	60	408.90 (66.84)	415.30 (67.52)
Sustainability Awareness (out of 5)	Experimental	60	3.15 (0.45)	4.25 (0.38)
	Control	60	3.12 (0.48)	3.20 (0.46)

To determine the statistical significance of the differences in posttest scores while controlling for initial proficiency, an ANCOVA was performed for each dependent variable.

The results of the ANCOVA for posttest English proficiency scores are shown in Table 2. After adjusting for the pretest scores, there was a statistically significant main effect for the group ($F(1, 117) = 45.21, p < 0.001$), with a partial eta-squared (η_p^2) of 0.279, indicating a large effect size. This suggests that the SDG-PBL intervention had a substantial positive impact on students' English proficiency compared to traditional instruction. The adjusted posttest mean for the experimental group ($M_{adj} = 465.15$) was significantly higher than that of the control group ($M_{adj} = 415.95$).

TABLE 2. ANCOVA for Posttest English Proficiency Scores

Source	df	F	Sig. (p)	Partial η^2
Covariate (Pretest Score)	1	987.65	< 0.001	0.894
Group	1	45.21	< 0.001	0.279
Error	117	—	—	—
Total	120	—	—	—

Similarly, the ANCOVA results for the posttest sustainability awareness scores, presented in Table 3, revealed a highly significant main effect for the group ($F(1, 117) = 156.83, p < 0.001$), with an η_p^2 of 0.573, indicating a very large effect size. This finding demonstrates that the SDG-PBL model had a statistically significant and substantial effect on enhancing students' sustainability awareness. The adjusted posttest mean for the experimental group ($M_{adj} = 4.24$) was substantially higher than that of the control group ($M_{adj} = 3.21$).

TABLE 3. ANCOVA for Posttest Sustainability Awareness Scores

Source	df	F	Sig. (p)	Partial η^2
Covariate (Pretest Score)	1	35.14	< 0.001	0.231
Group	1	156.83	< 0.001	0.573
Error	117	—	—	—
Total	120	—	—	—

In summary, the statistical analyses provide robust evidence to support both research hypotheses. The students who participated in the SDG-PBL model demonstrated significantly greater improvements in both their English language proficiency and their sustainability awareness compared to students who received traditional English language instruction.

V. DISCUSSION

This study was designed to quantitatively evaluate the effectiveness of an interdisciplinary SDG-PBL model in a university English education context. The findings directly address the research questions, indicating that the SDG-PBL intervention was significantly more effective than traditional instruction in enhancing both students' English language proficiency and their sustainability awareness. This section interprets these findings, explores the underlying pedagogical mechanisms responsible for the model's success, situates the results within the broader academic literature, and acknowledges the study's limitations while proposing directions for future research.

The primary finding of this research is the strong, statistically significant impact of the SDG-PBL model on both dependent variables. The large effect sizes observed for both English proficiency ($\eta_p^2 = 0.279$) and sustainability awareness ($\eta_p^2 = 0.573$) underscore the practical significance of the intervention. These results provide robust empirical support for the theoretical arguments that advocate for integrating ESD and ELT through active, student-centered pedagogies. The study demonstrates that such an integration is not a zero-sum game in which one objective is sacrificed for the other; rather, it creates a synergistic learning environment where language acquisition and sustainability literacy are mutually reinforcing.

The superior language gains of the experimental group can be attributed to the core principles of the PBL frame-

work. Unlike the control group, whose learning was often confined to decontextualized textbook exercises, the PBL group was immersed in a sustained, authentic communicative environment. The driving question related to fast fashion was not merely a topic for discussion but a complex, real-world problem that required a genuine information gap to be filled. This created a powerful intrinsic motivation for students to engage deeply with challenging English texts, analyze data, debate solutions, and articulate their findings persuasively. This process, which can be conceptualized as a “motivation-competency flywheel,” positioned language as the essential tool needed to solve a problem of personal relevance. The necessity of producing a high-quality public product for an authentic audience—a formal proposal and presentation—pushed students to achieve a higher level of linguistic precision and communicative competence than is typically demanded in traditional classroom settings. To contextualize the practical significance of this 55.3-point improvement, it is useful to reference the official linking study between the CET and the Common European Framework of Reference for Languages (CEFR). According to the study, a CET-4 score of 425 is benchmarked at the CEFR B1 level. The experimental group’s mean score improved from 410.50 (on the cusp of B1) to 465.80, moving them firmly into the B1 proficiency band. This suggests the intervention facilitated a meaningful consolidation of students’ ability to understand the main points of clear standard input on familiar matters and to produce simple connected text on topics that are familiar or of personal interest.

Furthermore, the dramatic increase in sustainability awareness, particularly in the self-reported behavioral dimension measured by the SAQ, suggests that the SDG-PBL model is effective in fostering the precursors to action competence. While self-reported behaviors are an indicator of intent and awareness, it is acknowledged that they are not a direct measure of demonstrated competence. The project-based process, which required students to formulate tangible solutions, likely cultivated the strategic thinking and sense of agency foundational to taking action, even if final competence was not directly assessed. Many sustainability education initiatives succeed in raising awareness but fail to empower students or foster a sense of agency. The PBL model, by design, bridges this gap. The requirement to move beyond research and develop a concrete, workable solution compelled students to transition from passive learners into active problem-solvers. They had to grapple with the practical complexities of their proposals, from budgeting to stakeholder engagement, thereby developing the strategic and collaborative skills essential for real-world change agents. This active engagement with a multifaceted problem such as fast fashion also fostered a more holistic understanding of sustainability. As observed in prior research, students often hold a narrow, environment-centric view of sustainability. The project compelled students to investigate the interconnected social (e.g., labor conditions in the garment industry), economic (e.g., business models of fast fashion

versus sustainable alternatives), and environmental (e.g., water pollution from textile dyes) dimensions of the issue, reflecting the integrated nature of the SDGs themselves.

These findings contribute significantly to the existing literature by providing the kind of rigorous, empirical validation that has been largely absent. While many studies have advocated for the benefits of combining ELT and ESD, this research offers a specific, replicable model and quantitative evidence of its dual effectiveness. The results align with and extend the findings of smaller-scale or qualitative studies that have reported positive outcomes in student engagement and critical thinking when sustainability content is incorporated into language teaching. By employing a quasi-experimental design with statistical controls, this study strengthens the causal claim that the pedagogical model itself, and not just pre-existing student differences, was responsible for the observed outcomes.

Despite the strong findings, this study has several limitations that must be acknowledged. First, the use of a non-randomized, quasi-experimental design means that the possibility of unmeasured confounding variables influencing the results cannot be entirely eliminated, although the use of ANCOVA mitigates this risk. Second, the study was conducted at a single university in China, which may limit the generalizability of the findings to other cultural and institutional contexts. The specific topic of fast fashion, while highly relevant to this group, may have different levels of resonance with students elsewhere. Third, the 16-week duration of the intervention, while corresponding to a full academic semester, is relatively short for assessing long-term changes in behavior and language retention. Finally, and most significantly, while the model is claimed to foster “action competence,” this study relied on a self-report questionnaire (the SAQ) to measure behavioral changes. As self-reported data can be influenced by social desirability bias and may not perfectly correlate with actual behavior, it serves as an indirect proxy rather than a direct measure of action competence. A more robust validation of this claim would require a performance-based assessment of the students’ final projects, such as evaluating the feasibility, rigor, and potential impact of their proposed solutions. Future research should incorporate such metrics to more rigorously assess the development of action competence. These limitations point toward several important directions for future research. Replication studies are needed in diverse educational settings and cultural contexts to test the robustness of the SDG-PBL model. Longitudinal studies could track students beyond the intervention period to assess the long-term impact on their academic performance, career choices, and sustainable lifestyle practices. Future research could also employ a mixed-methods approach, incorporating qualitative data from interviews and project analyses to provide a richer understanding of the student learning experience and the specific ways in which the PBL process fosters language skills and sustainability competencies. Finally, comparative studies could evaluate the SDG-PBL

model against other active learning pedagogies, such as task-based language teaching or content and language integrated learning (CLIL), to determine the relative effectiveness of different approaches for achieving the dual goals of ESD and ELT. Additionally, it is important to acknowledge the potential influence of the “novelty effect.” Given that the PBL methodology is a significant departure from the more traditional, teacher-centered instruction familiar to the students, the observed gains in the experimental group could be partially attributed to their increased motivation and engagement stemming from the novelty of the pedagogical approach itself, rather than solely from the integration of SDG-related content. To isolate the specific impact of the ESD component, future research should be designed to control for this effect. For instance, a valuable follow-up study could compare the current SDG-PBL model with another PBL group focused on a different, non-sustainability-related complex topic, which would help to disentangle the effects of the pedagogy from the effects of the content.

VI. CONCLUSION

In response to the urgent need for educational models that can address the complex challenges of the 21st century, this study investigated the effectiveness of an interdisciplinary project-based learning model designed to integrate Sustainable Development Goals into university-level English language teaching. The research sought to determine whether such a model could simultaneously enhance students' English proficiency and their sustainability awareness more effectively than traditional instructional methods. The quantitative results of the quasi-experimental study provide a definitive and affirmative answer. The SDG-PBL model led to statistically significant and substantial improvements in both linguistic competence and sustainability literacy, demonstrating a powerful synergy between the two domains.

The primary contribution of this paper is the provision of robust, empirical evidence for a specific and replicable pedagogical framework that effectively bridges the gap between ELT and ESD. The findings show that by grounding language learning in the authentic, meaningful, and urgent context of global sustainability challenges, educators can foster deeper student engagement and achieve superior learning outcomes. The PBL methodology proved to be a potent vehicle for this integration, transforming the language classroom into a dynamic laboratory for collaborative inquiry, critical problem-solving, and the development of real-world action competence.

The implications of this research are significant for a range of educational stakeholders. For English language educators, this study offers a validated model for moving beyond conventional curricula to design instruction that is more relevant, motivating, and impactful. For curriculum designers and university administrators, it provides a clear rationale for strategically embedding ESD across disciplines, highlighting the unique potential of the ELT classroom to cultivate global citizenship. Ultimately, this

research reinforces the conviction that language education must play a central role in the global effort to achieve a sustainable future. By equipping students with both the linguistic tools and the critical consciousness to engage with the world's most pressing issues, we can better prepare them to not only navigate but also actively shape a more just, equitable, and sustainable world.

AUTHOR CONTRIBUTIONS

Zhiguo Zhang designed, collected and analyzed the data, and drafted the manuscript. Zhiguo Zhang conducted the study, critically revised the manuscript for important intellectual content, and gave final approval of the version to be published. Zhiguo Zhang participated fully in the work, take public responsibility for appropriate portions of the content, and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICT OF INTEREST

The author declares no conflict of interest.

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ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This survey was conducted in compliance with Ethics Committee of Inner Mongolia University of Science and Technology. Participants were informed of the study's purpose and data usage prior to participation, and responses were collected anonymously. No personally identifiable information was stored.

AVAILABILITY OF DATA AND MATERIALS

The datasets used and/or analysed during the current study were available from the corresponding author on reasonable request.

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