PLACE BASED AND CULTURALLY RESPONSIVE REFORM OF AN INTRODUCTION TO ENVIRONMENTAL SCIENCE COURSE IN QINGHAI ON THE QINGHAI TIBETAN PLATEAU: CURRICULUM DESIGN AND AN OUTCOMES EVALUATION FRAMEWORK

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Abstract: Qinghai Province lies in western China on the northeastern margin of the Qinghai Tibetan Plateau and is widely recognized for both ecological vulnerability and cultural diversity. Local environmental issues such as watershed security in headwater regions, grassland degradation, solid waste pressures linked to urbanization and tourism, and climate related hazards are not only biophysical problems but also questions of livelihoods, cultural practice, and governance. In many universities serving this region, the Introduction to Environmental Science course remains organized around generic textbook chapters and lecture centered delivery. Such arrangements often fragment students' understanding of ecological systems and provide limited opportunities to practice evidence based inquiry, reasoning about trade offs, or communicating across cultural and linguistic differences. Drawing on place based education and the critical pedagogy of place, and on culturally relevant, culturally responsive, and culturally sustaining perspectives, this paper develops a localized curriculum reform for the course and a coherent outcomes evaluation framework aligned with Education for Sustainable Development. The reform integrates local issue driven project units with core disciplinary concepts, adopts project based learning and authentic assessment as the primary instructional approach, and embeds participation supports intended to reduce inequities in multiethnic classrooms. The evaluation framework specifies measurable learning outcomes across conceptual understanding, environmental attitudes and literacy, systems thinking, evidence based decision making, and intercultural collaboration, and it proposes a mixed methods analytic strategy combining pre and post measures, rubric scored artifacts, classroom analytics, and qualitative analyses of interviews and learning journals. As a design based study, the paper reports the resulting curriculum architecture, task sets, and scoring tools as concrete products that can be adapted by universities in other multiethnic and environmentally sensitive regions.

Keywords: Environmental science education; Place based education; Culturally responsive teaching; Multiethnic higher education; Qinghai Tibetan Plateau; Project based learning; Authentic assessment; Environmental literacy; Education for Sustainable Development

1 INTRODUCTION

1.1 Background and Problem Statement

Qinghai Province is located in western China and forms part of the Qinghai Tibetan Plateau, a region often described as ecologically fragile and sensitive to external disturbances [1,2]. Qinghai is also a multiethnic province in which ethnic minority populations constitute a substantial share of residents [3]. These features are not simply contextual details; they shape what environmental problems look like, whose interests are affected, and how solutions are negotiated. For example, discussions about water security and watershed management in headwater regions are inseparable from questions of upstream downstream equity, land use regimes, and community participation, and contemporary research continues to refine widely held assumptions about the plateau's contribution to runoff and downstream water supply [4]. Similarly, issues such as pasture degradation, biodiversity protection, and waste management often sit at the intersection of ecological processes, economic development priorities, and cultural traditions. Yet, in many higher education settings, the Introduction to Environmental Science course is still organized as a survey of concepts and pollutant categories delivered through lectures and decontextualized examples. Students may memorize terms without learning how to frame problems, evaluate evidence, or communicate with stakeholders, and this limitation becomes more visible in multiethnic classrooms where language practices and communicative norms vary. In such settings, the course can inadvertently reproduce inequities by privileging students whose academic discourse aligns most closely with dominant classroom styles while marginalizing the knowledge resources and lived experiences of others.

1.2 Purpose and Research Questions

Responding to these challenges, the present study develops a place based and culturally responsive reform of the Introduction to Environmental Science course, using Qinghai as a case of a plateau region where environmental issues are tightly coupled with cultural diversity. The immediate goal is practical: to propose a course structure that links local issues to core disciplinary concepts, supports student inquiry through project based learning, and assesses learning through authentic tasks and transparent rubrics. The broader goal is scholarly: to articulate design principles and an outcomes evaluation framework that can inform environmental and sustainability education in other multiethnic regions. The paper addresses three questions. First, how can course content be reconstructed around local issues so that conceptual learning is continuously connected to evidence and decision contexts, rather than presented as an isolated body of knowledge. Second, how can culturally relevant and sustaining supports be embedded in everyday teaching routines to promote equitable participation, collaborative communication, and professional identity development among students from different ethnic and linguistic backgrounds. Third, how can an assessment system be designed so that learning outcomes such as environmental literacy, systems thinking, and evidence based reasoning are evaluated with validity and transparency, using a mixed methods approach suited to complex educational interventions [5].

2 LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2.1 Place based Education and the Critical Pedagogy of Place

Place based education has been advanced as a way to ground learning in the local community and natural environment so that knowledge becomes intelligible through the conditions of everyday life rather than as an abstract body of facts. Within environmental education, this tradition typically foregrounds experiential learning, attention to local ecological processes, and civic engagement. However, critiques of purely celebratory place based approaches have noted that places are also sites of contestation, where historical trajectories, governance arrangements, and uneven power relations shape access to resources and exposure to environmental risks. Gruenewald argued that critical pedagogy and place based education can be brought into productive dialogue through a critical pedagogy of place that asks educators to consider both reinhabitation, meaning the development of sustainable relationships with local ecosystems, and decolonization, meaning the interrogation of social and cultural structures that marginalize some communities [6]. Greenwood further emphasized that environmental education benefits from acknowledging difference and standpoint, because multiple perspectives can expand inquiry rather than producing gridlock [7]. For environmental science teaching in Qinghai, these arguments imply that local cases should be treated as more than illustrative examples; they should become the organizing backbone of the curriculum, prompting students to analyze how ecological vulnerability, livelihood strategies, and governance choices interact at different spatial and temporal scales. In this sense, place is a bridge between scientific concepts and ethical decision making, and a critical place perspective can help students learn to work with evidence while also recognizing that environmental problems are lived and negotiated by communities.

2.2 Culturally Relevant, Culturally Responsive, and Culturally Sustaining Pedagogy

Environmental issues in multiethnic regions are always interpreted through cultural frames, and students' willingness to engage in environmental learning often depends on whether their histories and lived experiences are treated as legitimate forms of knowledge. Ladson Billings described culturally relevant pedagogy as a framework that integrates academic achievement, cultural competence, and critical consciousness, rejecting deficit views of students from nondominant groups and instead positioning culture as a resource for learning [8]. Gay elaborated culturally responsive teaching as the deliberate use of students' cultural knowledge and communicative practices to make instruction more effective, which has implications for curriculum materials, discourse norms, and assessment [9]. Paris extended this line of work by advocating culturally sustaining pedagogy, emphasizing that schooling should sustain linguistic and cultural pluralism rather than assimilating students into a single dominant norm [10]. In Qinghai higher education, culturally responsive approaches can address two practical needs at once: the need to broaden participation and the need to enrich environmental reasoning with diverse forms of place knowledge. Concretely, these approaches suggest the value of multimodal resources, opportunities for students to draw on local languages and community knowledge in sense making, and group work structures that distribute voice and responsibility. They also suggest that equity is not an add on but a design criterion, because who speaks and whose evidence is regarded as credible shapes how students learn to think about environmental governance and sustainability.

2.3 Project based Learning and Authentic Assessment

Project based learning is widely defined as an instructional approach in which students engage over an extended period with complex questions or problems that culminate in a publicly shareable product. In their review, Kokotsaki, Menzies, and Wiggins showed that PBL is most likely to produce positive learning outcomes when projects are structured around meaningful driving questions, when teachers provide timely scaffolding, and when assessment practices are aligned with intended outcomes [11]. These findings are particularly relevant for introductory environmental science because students must integrate multiple knowledge sources, handle uncertainty, and communicate to audiences beyond the classroom. Authentic assessment offers a complementary rationale for evaluation. Wiggins argued that assessment becomes authentic when it directly examines performance on intellectually worthy tasks rather than relying on proxy items that may reward rote recall [12]. Gulikers, Bastiaens, and Kirschner proposed a multidimensional framework for

authenticity that includes the task itself, its physical and social context, the nature of the assessment product, and the criteria used to judge it [13]. Taken together, these perspectives suggest that assessment in a reformed Introduction to Environmental Science course should prioritize evidence rich products such as policy memos, monitoring plans, or risk communication artifacts, accompanied by transparent rubrics that represent disciplinary standards while leaving room for local and cultural specificity. In this paper, PBL is adopted as the primary instructional engine, and authentic assessment is treated as the quality control mechanism that keeps learning activities, outcomes, and evaluation in alignment.

2.4 Environmental Literacy and Education for Sustainable Development

Environmental literacy has been conceptualized as a composite of knowledge, dispositions, and competencies that enable individuals to identify environmental issues, analyze causes, evaluate solutions, and take informed action. The Revised New Ecological Paradigm scale developed by Dunlap, Van Liere, Mertig, and Jones remains among the most widely used instruments for measuring pro environmental worldviews, and it provides a useful component for evaluating attitudinal change in higher education settings [14]. For broader competency mapping, Hollweg and colleagues proposed an environmental literacy assessment framework that differentiates knowledge of ecological and socio political systems, competencies for issue analysis and decision making, and dispositions toward the environment [15]. At the policy level, UNESCO's Education for Sustainable Development roadmap emphasizes that education should equip learners with knowledge, skills, values, and behaviors that support the environment, the economy, and society, while also strengthening education systems and learning environments [16]. For a course situated in Qinghai, an environmental literacy lens prevents evaluation from collapsing into content recall alone, while an ESD lens helps link local issues to broader sustainability goals, including equity and participation. In this study, environmental literacy and ESD jointly inform the outcomes framework, the selection of tasks, and the design of instruments for capturing learning in ways that are meaningful both locally and internationally.

3 METHODS

3.1 Research Design and Overall Approach

The study is framed as design based research, an approach that blends theory driven design with empirical inquiry in authentic settings and seeks to generate both practical improvements and transferable knowledge about why an innovation works [17,18]. In the context of a university course, design based research is compatible with participatory action research, which emphasizes iterative cycles of planning, acting, observing, and reflecting with practitioners and learners as co participants [19]. The reform reported here therefore treats curriculum development as a cycle of design decisions that are continuously tested against the realities of a multiethnic classroom. The paper documents the resulting curriculum architecture and provides an outcomes evaluation framework that can be used to study learning impacts through mixed methods. In line with mixed methods logic, the evaluation plan integrates quantitative measures (knowledge, attitudes, rubric scores) with qualitative evidence (interviews, journals, observation notes, artifact analysis) to support both outcome claims and explanatory insights about mechanisms [5].

3.2 Context, Course Setting, and Participants

The reform is designed for the compulsory Introduction to Environmental Science course offered in universities in Qinghai. The course typically enrolls first and second year undergraduates from different majors, including environmental science related programs and general education tracks, and it includes students from Han and multiple ethnic minority groups. While the present paper does not rely on a single institution's administrative data for its claims, the design assumptions are grounded in widely observed conditions in the region: students bring diverse language repertoires, some have direct experience with pastoral or agricultural livelihoods, and many are motivated by regional issues such as water security, nature reserve governance, and green development. The intervention therefore treats linguistic diversity and varied place experiences as design inputs rather than implementation constraints, and it seeks to provide multiple entry points for participation in inquiry and assessment.

3.3 Intervention Description: Curriculum Architecture and Instructional Routines

The reformed course is organized as a sequence of local issue driven project units. Each unit is built around a driving question that cannot be answered through recall alone, requires the use of evidence, and forces students to reason about trade offs. Core disciplinary concepts are introduced through short targeted lectures and guided readings, then applied through sustained inquiry and product development. Instruction follows a six phase routine: an entry event that introduces a local issue through data or media, refinement of a driving question and success criteria, evidence gathering and analysis supported by methodological mini lessons, iterative solution development with checkpoints, public presentation to an authentic audience, and structured reflection that feeds into subsequent units. Throughout the course, culturally responsive participation supports are embedded in group formation, language scaffolds, and multimodal communication options. Assessment is anchored in authentic products and transparent rubrics, with formative feedback provided at multiple stages so that evaluation functions as part of learning rather than as a terminal judgment [12,13].

3.4 Data Sources and Instruments for Outcomes Evaluation

The evaluation framework proposes four complementary streams of evidence. First, conceptual learning and systems understanding can be assessed through scenario based tests administered pre and post, combining multiple choice items that capture key concepts (e.g., watershed processes, pollution pathways, ecological carrying capacity) with constructed response tasks requiring causal explanations and solution justification. Second, dispositions and attitudes can be examined using validated scales, including the Revised New Ecological Paradigm scale as a measure of ecological worldview, alongside a tailored environmental literacy questionnaire informed by the NAAEE framework [14,15]. Third, performance outcomes are captured through rubric scored project artifacts, including policy memos, monitoring plans, stakeholder maps, and risk communication products. The analytic rubric includes dimensions for evidence quality, systems reasoning, solution feasibility, equity and cultural responsiveness, and communication effectiveness. Fourth, process and mechanism evidence is collected through structured classroom observations, student learning journals, focus group interviews, and reflective interviews with instructors. Together, these sources support triangulation: quantitative shifts can be interpreted in light of qualitative accounts of participation, sense making, and identity.

3.5 Quantitative and Qualitative Analysis Framework

Quantitative analyses focus on estimating the magnitude and uncertainty of learning changes. Pre post comparisons for knowledge scores and scale measures can be examined using paired samples t tests when distributional assumptions are met, or Wilcoxon signed rank tests as a robust alternative. When multiple sections or demographic groups are compared, ANCOVA models can be used to adjust post scores for pre scores, and interaction terms can explore whether the intervention is associated with differential gains. Effect sizes (Cohen's d or r) and confidence intervals should be reported to avoid over reliance on p values. Scale reliability should be assessed with internal consistency indices such as Cronbach's alpha, and, when sample size permits, factorial validity can be explored using exploratory or confirmatory factor analysis to check whether the adapted instruments retain expected structure. For rubric scored artifacts, inter rater reliability should be estimated using intraclass correlation coefficients and rater calibration sessions should be documented. Qualitative analyses are structured around thematic analysis. Observation notes, interviews, and learning journals can be coded inductively and deductively, with a codebook that includes categories aligned to the conceptual framework (e.g., evidence use, systems connections, cultural references, equity concerns, collaboration dynamics) while leaving room for emergent themes. Credibility can be strengthened through double coding of a subset of data, discussion of discrepancies, and member checking with participants where feasible. Mixed methods integration occurs through joint displays that align numeric trends with qualitative explanations, for example by linking shifts in environmental worldview scores to narrative accounts of how students negotiated value conflicts in projects [5].

3.6 Ethical Considerations and Quality Assurance

Ethical practice is central when curriculum work involves community issues and cultural knowledge. Data collection should be conducted with informed consent, clear options to opt out of research participation without academic penalty, and careful protection of student identity in publications. When community stakeholders are involved as authentic audiences, their role should be negotiated to avoid extractive use of local knowledge, and student outputs should not be represented as official policy advice. Quality assurance includes transparent documentation of design decisions, maintenance of an audit trail linking data to interpretations, and explicit reporting of limitations such as nonrandom assignment or small sample sizes in single course settings. These measures align the study with best practices for rigorous educational design research, see Table 1.

Table 1 Outcomes, Evidence Sources, and Analysis Plan

Outcome domain	Evidence source	Representative indicators	Primary analysis
Conceptual understanding and transfer	Scenario based pre/post test; short constructed responses	Accurate causal explanation; correct use of core concepts; transfer to Qinghai cases	Paired t test or Wilcoxon; effect size; item analysis
Environmental attitudes and dispositions	Revised NEP; environmental literacy questionnaire	Change in ecological worldview; perceived responsibility; willingness to act	Reliability (α); pre/post comparison; subgroup analysis when appropriate
Systems thinking and evidence based decision making	Project artifacts scored with analytic rubric	Quality of evidence; explicit trade off reasoning; multi scale system map; solution feasibility	Rubric score distributions; ICC for rater reliability; correlations with test scores
Intercultural collaboration and participation equity	Observation protocol; peer assessment; group process logs; interviews	Turn taking balance; role rotation; conflict resolution; inclusion of local knowledge	Thematic analysis; joint displays linking themes to performance trends

4 RESULTS

4.1 The Localized Curriculum Structure

The first product of the design work is a curriculum architecture that interleaves local environmental issues with core concepts in environmental science. Instead of sequencing the course by pollutant type or disciplinary subfield, the course is organized by regional problems that naturally require students to draw on hydrology, ecology, atmospheric science, geochemistry, and environmental policy. Each unit follows a consistent pattern: students begin with a locally recognizable situation, identify what counts as credible evidence, map the socio ecological system and stakeholders, and then design and communicate a feasible response. This structure reduces fragmentation by repeatedly returning students to a small set of recurring intellectual moves: issue framing, causal reasoning, system mapping across scales, evaluation of alternative solutions, and communication to audiences. Across units, conceptual goals spiral rather than accumulate linearly, so that foundational ideas such as carrying capacity, feedback, threshold effects, and risk trade offs are revisited in new contexts. The design therefore treats core content as a set of tools for reasoning about place, aligning with a critical pedagogy of place that links reinhabitation and decolonization to disciplinary learning [6,7].

4.2 Project Units and Driving Questions.

Five exemplar units were developed to cover the breadth of introductory environmental science while staying anchored in Qinghai's plateau context. The first unit, Watersheds and headwater security, uses the region's role as a source area for major rivers to examine watershed processes, water quality indicators, and governance tensions between conservation and development, drawing attention to contemporary scientific debates about runoff contributions and water tower narratives [4]. A typical driving question asks: What combination of monitoring, demand management, and policy coordination would most effectively protect downstream water quality while respecting local livelihood needs. The second unit, Grasslands, soils, and livelihood change, examines land degradation, soil erosion, and the ecological consequences of grazing intensity, with students modeling causal pathways and exploring how ecological vulnerability varies across the plateau [2]. The third unit, Urbanization, tourism, and solid waste, addresses waste classification, life cycle thinking, and the infrastructure challenges of managing waste streams in cold, high altitude environments. The fourth unit, Biodiversity and protected areas, centers on ecological networks, habitat fragmentation, and the governance of protected areas, including the role of community co management. The fifth unit, Climate change and disaster risk, connects regional warming trends to glacier and snow dynamics, extreme weather events, and adaptation strategies. Each unit culminates in a product designed for a plausible audience such as a park management committee, a county environmental bureau, a community association, or a campus sustainability office. This audience orientation is not decorative; it forces students to translate scientific language into actionable recommendations and to anticipate counterarguments rooted in values and constraints.

4.3 Task Design and Instructional Scaffolds

To make extended inquiry feasible in an introductory course, each project is decomposed into a sequence of checkpoints that progressively build disciplinary competence. Early checkpoints require students to construct a shared evidence base, often by working with a curated packet that includes short research articles, statistical tables, monitoring datasets, and policy excerpts. Subsequent checkpoints prompt students to create system representations such as causal loop diagrams, stakeholder influence maps, and simple mass balance or water budget models. Mini lessons are then offered responsively to address methodological needs that emerge from student work, for example how to interpret remote sensing images, how to distinguish correlation from causation in environmental data, or how to evaluate uncertainty and data limitations. Teachers also provide language scaffolds that support academic discourse, including structured sentence frames for claims and evidence, bilingual glossaries for key terms, and templates for executive summaries. These supports are designed so that academic rigor is not lowered but access is widened, consistent with culturally responsive teaching principles [9]. Importantly, students are required to revise products after feedback, which shifts assessment from one time performance to a process of improvement and makes rubric criteria consequential for learning.

4.4 Embedding Culturally Responsive Participation Supports

The reform specifies participation routines intended to reduce inequities that can appear in multiethnic classrooms. Group formation is intentional and dynamic: teams are constructed to include different majors and backgrounds, and roles rotate across projects so that the same students do not repeatedly become translators, note takers, or presenters. Role expectations are made visible through short behavioral descriptors so that peer evaluation can focus on observable contributions rather than vague impressions. To support linguistic pluralism while maintaining academic standards, the course allows students to use local languages in early sense making discussions, especially when eliciting place knowledge and community perspectives, while final products require a common academic language and a short bilingual abstract where feasible. Multimodal options are also built into products: students may combine maps, infographics, short videos, and narrative accounts alongside formal scientific writing. These design choices respond to the core idea of culturally sustaining pedagogy that education should sustain cultural and linguistic resources rather than treating them as barriers [10]. In the Qinghai context, where some students have direct experience with pastoral landscapes and others have urban backgrounds, these supports also broaden what counts as relevant experience in environmental reasoning, without substituting experience for evidence.

4.5 The Authentic Assessment System and Rubric Structure

The second major product is an assessment system that aligns with project based learning and environmental literacy outcomes. Following the rationale of authentic assessment and multidimensional authenticity, the system uses two categories of evidence: performance products and learning reflections [12,13]. Performance products include a main deliverable for each unit and supporting artifacts such as system maps, annotated bibliographies, and data analysis worksheets. Learning reflections include short individual memos in which students explain how their thinking changed, what evidence shifted their view, and how they navigated value conflicts in group work. The analytic rubric is the main scoring tool. Rather than collapsing quality into a single score, the rubric makes disciplinary standards explicit through dimensions for evidence quality, systems reasoning, feasibility of recommendations, attention to equity and cultural context, and communication for the intended audience. The rubric is designed for formative use: drafts are scored at checkpoints, students receive narrative feedback linked to criteria, and revisions are expected. This makes the assessment system both more transparent and more instructionally useful, and it provides richer data for evaluation than a final exam alone, see Table 2.

Table 2 Excerpt from the Analytic Rubric for Project Products

Dimension	Beginning	Developing	Proficient	Advanced
Use of evidence	Claims are largely unsupported; sources are missing or not credible.	Uses some sources but evidence is selectively interpreted or weakly linked to claims.	Uses multiple credible sources; explains how evidence supports claims; notes limitations.	Synthesizes diverse evidence (data, literature, policy); evaluates uncertainty and alternative explanations.
Systems reasoning	Lists factors without explaining relationships or feedback.	Identifies some causal links but system boundaries and scale are unclear.	Explains causal pathways and interactions across ecological and social components; considers scale.	Models feedback, thresholds, and trade offs; articulates how interventions may shift system behavior over time.
Feasibility and ethics	Recommendations are vague, unrealistic, or ignore constraints and affected groups.	Recommendations address the issue but feasibility, costs, or equity are only partly considered.	Recommendations are feasible in the local context; considers constraints, trade offs, and equity impacts.	Recommendations integrate technical, economic, cultural, and governance considerations; anticipates objections and proposes mitigation.
Communication for audience	Message is unclear; structure and visuals hinder understanding.	Basic structure is present but key messages or visuals are inconsistent.	Clear, well structured communication; visuals support interpretation; appropriate tone for audience.	Compelling narrative with concise executive summary; strong visual communication; adapts language for diverse audiences.

4.6 The Mixed Methods Outcomes Evaluation Framework

The evaluation framework operationalizes environmental literacy and ESD aligned outcomes into indicators that can be measured without reducing the complexity of learning. The knowledge component distinguishes between ecological system understanding and knowledge of socio political systems, consistent with environmental literacy frameworks [15]. Competency indicators focus on the ability to identify and frame issues, analyze evidence, evaluate solutions, and justify actions, while disposition indicators include ecological worldview and perceived efficacy. Importantly, the framework also treats intercultural collaboration as an outcome rather than a mere process variable, because in multiethnic contexts collaboration is a competency with real social consequences. In reporting, the framework encourages the use of joint displays that show how quantitative shifts align with qualitative themes. For example, a joint display might juxtapose changes in students' NEP scores with excerpts from reflection memos where students describe how their beliefs were challenged by evidence about trade offs between conservation and local livelihoods. Similarly, rubric score trajectories on the systems reasoning dimension can be interpreted alongside observation notes about group dialogue patterns, such as whether students explicitly connected upstream land use to downstream water quality or whether system maps remained linear and simplistic. These forms of integration align with mixed methods design logic and are particularly suited to design based research where understanding mechanisms matters as much as documenting outcomes [5,17].

4.7 Reporting Templates for Quantitative and Qualitative Results

To support replicable reporting, the framework includes a set of reporting conventions that can be adopted when empirical data are collected. Quantitative reporting should begin with descriptive statistics (means, standard deviations, score distributions) and reliability indices for all scales and rubrics, followed by pre post comparisons with effect sizes and confidence intervals. Where subgroup comparisons are relevant, demographic variables should be reported descriptively and interpreted cautiously, with attention to the fact that linguistic and cultural identities do not map neatly onto performance patterns. Qualitative reporting should include a transparent description of data volume, coding

procedures, and representative excerpts for major themes. Themes are most persuasive when they are linked to concrete episodes of project work, such as moments when groups negotiated which evidence sources were credible or how to frame an audience facing competing pressures. Finally, mixed methods integration should be explicit rather than implied: tables or narrative joint displays should state what qualitative themes explain or complicate quantitative patterns and what unresolved tensions remain. These templates are included because they reduce the risk that future empirical studies of the reform will rely on generic claims; they also make it easier for instructors to treat evaluation as part of iterative improvement.

5 DISCUSSION

5.1 Contributions to Environmental Science Education in Multiethnic Contexts

The central contribution of this paper is to show how an introductory environmental science course can be redesigned so that place, culture, and evidence become mutually reinforcing rather than competing priorities. The curriculum architecture treats local issues as organizing problems that repeatedly require students to use disciplinary concepts for explanation and action, which addresses a common weakness of survey courses where concepts remain disconnected from decision contexts. At the same time, culturally responsive and sustaining supports are embedded in routine teaching practices, not reserved for special topics. This matters because multiethnic classrooms often face a double risk: inequities in participation can mirror broader social hierarchies, and environmental topics can become politically or culturally sensitive when they touch on land use, livelihood change, or governance. By making participation structures explicit and by valuing local knowledge while insisting on evidence based justification, the design aims to cultivate a professional identity in which students learn to see themselves as credible contributors to regional sustainability work. From a theoretical standpoint, the design operationalizes the critical pedagogy of place by treating reinhabitation as a scientific learning goal and decolonization as an equity and participation goal, thereby making the concept actionable in course design [6,7].

5.2 Implications for Assessment and Evaluation

A second contribution lies in the outcomes evaluation framework. Environmental science education reforms often struggle to evaluate outcomes that go beyond content recall. The framework presented here makes those outcomes measurable by linking them to observable products and behaviors. By combining validated attitude measures such as the Revised NEP with performance based rubrics aligned to environmental literacy competencies, the framework balances psychometric traditions with authentic assessment traditions [14,15]. This balance is important because the skills demanded by ESD, such as reasoning about trade offs and acting under uncertainty, are difficult to capture through conventional exams [16]. The mixed methods design further acknowledges that numbers alone rarely explain why learning changes, especially when interventions include changes in classroom culture, participation norms, and identity. The proposed integration strategy, using joint displays and mechanism oriented qualitative analyses, provides a practical way to report outcomes without oversimplifying them [5].

5.3 Limitations and Directions for Future Research

Because this paper is primarily a design report, it does not present large scale empirical outcome estimates. The next step is systematic implementation and evaluation across cohorts and institutions, with careful documentation of fidelity and local adaptation. Future studies should also examine how language supports interact with disciplinary rigor, for example whether bilingual scaffolds help students articulate more precise causal explanations or whether they primarily affect participation patterns. Another promising direction is to investigate how different types of authentic audiences influence student motivation and quality of reasoning, since stakeholder presence can both motivate and constrain what students are willing to argue. Finally, researchers should treat cultural responsiveness as an empirical question as well as a normative commitment by examining whether participation equity and learning gains are distributed more evenly across student groups under the redesigned course. Such work will strengthen the evidence base for place based environmental science education in culturally diverse regions and will contribute to international conversations about sustainability education that is both locally grounded and globally informed.

6 CONCLUSION

This paper developed a place based and culturally responsive reform for an Introduction to Environmental Science course situated in Qinghai on the Qinghai Tibetan Plateau. The reform responds to the intertwined ecological and cultural characteristics of the region by reorganizing content around local issue driven projects, embedding culturally sustaining participation supports, and adopting authentic assessment as the main evaluation approach. The paper also specified an outcomes evaluation framework that aligns environmental literacy with Education for Sustainable Development goals and that offers a mixed methods analytic strategy capable of capturing both learning outcomes and the mechanisms that produce them. Although future empirical studies are needed to estimate impact, the curriculum architecture, task sets, and rubrics reported here provide a concrete pathway for universities seeking to localize

introductory environmental science teaching in multiethnic contexts while maintaining rigorous evidence based reasoning and transparent assessment.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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