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EcoQuest: A Gamified Web Platform for Environmental Learning and Real-World Action

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Abstract - *Environmental education often communicates sustainability concepts without consistently connecting learning to practical participation. EcoQuest is proposed as a gamified web platform that combines environmental learning content with quests, quizzes, points, badges, progress tracking, and a leaderboard. A review of the project's literature survey considers research on gamified environmental education and four existing platforms: Litterati, JouleBug, EcoChallenge, and iNaturalist. These services demonstrate approaches to litter tracking, sustainable-habit challenges, community action, and biodiversity observations, while serving different primary purposes. EcoQuest's proposed design brings learning and structured participation into one workflow. The paper describes the project motivation, related work, system architecture, development approach, and planned evaluation. The core prototype is intended to be assessed through functional testing, responsive-interface checks, and usability feedback. Learning outcomes and sustained engagement would require a separate empirical evaluation. Since the supplied project materials do not contain completed user-study measurements, no quantitative improvements or verified impact are claimed. Future work may include activity verification, location-based challenges, AI-assisted personalization, and richer 3D ecosystem exploration after the core system has been implemented and evaluated.*

Keywords - environmental education, gamification, sustainability, web platform, quests, environmental action, EcoQuest

I. INTRODUCTION

Environmental challenges such as littering, biodiversity loss, and unsustainable resource use require both public awareness and meaningful participation. However, environmental education can remain theoretical when learners have limited opportunities to apply what they learn through practical activities.

Gamification introduces game elements such as quests, points, badges, progress indicators, and leaderboards into non-game activities. Research on gamified environmental learning suggests that these mechanisms can support engagement and environmental awareness [1], [2]. Existing digital platforms also demonstrate useful approaches to tracking litter, encouraging sustainable habits, organizing community challenges, and recording biodiversity observations [4]–[7].

EcoQuest proposes to connect these approaches in one web platform. Its core workflow combines environmental learning, quests, quizzes, points, badges, progress tracking, and a leaderboard. Interactive ecosystem exploration and activity verification are planned extensions. This paper presents the motivation, related work, proposed design, and evaluation plan; it does not claim measured effectiveness before user testing.

II. RELATED WORK

A. Gamified Environmental Learning: Papakostas and Stergiou examined EcoHeroes, a gamified mobile-learning application for environmental education in primary school [1]. Talavera-Mendoza et al. studied gamification in relation to ecological awareness and pro-environmental intentions among high-school students [2]. These studies inform EcoQuest's use of quests and rewards, although their findings should not be assumed to prove the effectiveness of this particular platform.

B. Environmental Education Goals: Environmental learning is relevant to the United Nations Sustainable Development Goals, particularly SDG 4 (Quality Education) and SDG 13 (Climate Action) [3]. EcoQuest aims to make learning more participatory by linking educational content to structured activities. The extent to which this approach improves learning or sustained participation must be evaluated empirically.

C. Existing Platforms: The project literature survey compared four platforms. Litterati uses photo-based litter tracking and location information [4]. JouleBug encourages sustainable habits through challenges, points, badges, and teams [5]. EcoChallenge supports community-based environmental challenges and action tracking [6]. iNaturalist enables users to record biodiversity observations and contribute citizen-science data [7]. The survey identified a design opportunity to bring learning, quests, rewards, and real-world environmental action together, while recognizing that the platforms serve different primary purposes.

III. METHODOLOGY

EcoQuest follows a prototype-oriented development process: identify the learning and participation problem; define requirements; design the interface and data model; implement core learning and gamification features; and test the resulting workflows. The current project description defines the proposed system and test plan. Quantitative user-study results are not available in the supplied materials.

A. System Design

The proposed architecture contains a responsive presentation layer, application logic, persistent data storage, and gamification features. HTML and CSS are planned for the user interface, Python for backend logic and APIs, and a database for user accounts, quests, scores, badges, and progress. The core modules are registration/login, learning content, quest selection and completion, score tracking, badges, and a leaderboard. Advanced modules such as AI-based personalization, location-aware challenges, activity verification, and richer 3D ecosystem exploration are future work.

B. Core User Workflow

The intended workflow is: a user registers or logs in; explores environmental learning content; selects a quest; completes the described activity; submits the required completion information; and receives points or badges according to the system rules. The leaderboard and progress view display accumulated activity. Any claim that a real-world task has been completed must depend on a defined verification process; it should not be treated as verified merely because a user marks it complete.

IV. RESULTS AND EVALUATION PLAN

The supplied project materials describe the proposed features and testing approach but do not provide measured performance results or a completed user evaluation. Therefore, this section defines the evidence required to assess the prototype rather than reporting unverified outcomes. Table I summarizes core modules and their planned checks.

TABLE I Core Modules and Planned Evaluation Evidence

Module	Purpose	Planned Evaluation
Learning + Quests	Present content and environmental tasks	Check content and quest display
Points + Badges	Reward completed eligible activities	Verify award rules and score updates
Progress Tracking	Store completed quests and user progress	Check persistence after login
Leaderboard	Display ranking based on recorded scores	Verify ordering against stored scores

Functional testing should verify account registration and login, correct display of quests, prevention of rewards for incomplete tasks, accurate score and badge updates, persistence of progress, and leaderboard ranking. Responsive behavior should be checked at desktop and mobile screen widths. Usability testing should ask representative users to complete common tasks and collect feedback. Engagement and learning outcomes require a separate evaluation using defined measures before and after use; no such results are claimed here.

[Proposed workflow figure: Learn → Select Quest → Complete Activity → Record Progress → Earn Rewards]

Fig. 1. Proposed EcoQuest user workflow.

PROTOTYPE SCREENSHOTS

The following screenshots show the main pages of the EcoQuest web prototype: the home page, learning page, environmental missions, and leaderboard. They illustrate the interface layout; they do not by themselves confirm that every feature is connected to a live backend.

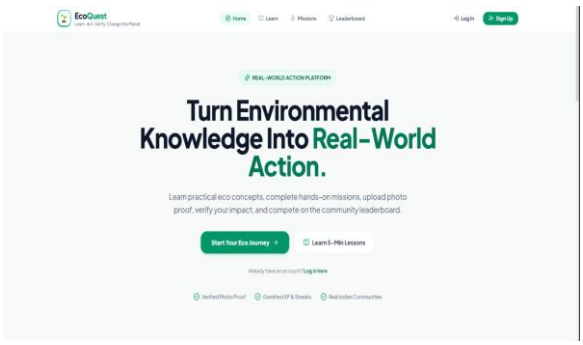


Fig. 2. EcoQuest home page.

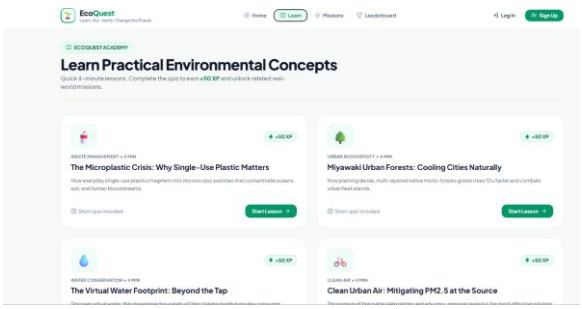


Fig. 3. Environmental learning page.

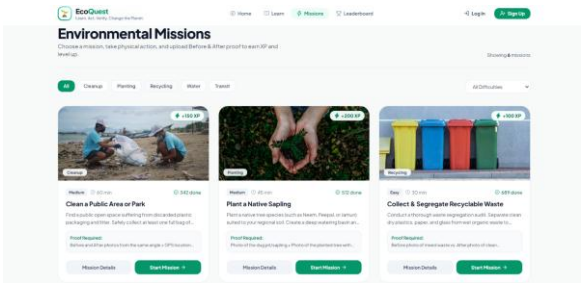


Fig. 4. Environmental missions page.

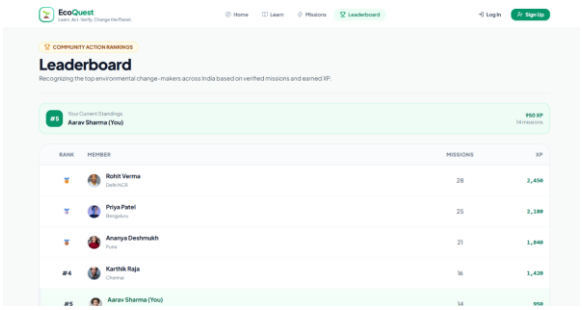


Fig. 5. Community leaderboard page.

SUPPLEMENTARY SYSTEM DESIGN AND IMPLEMENTATION DETAILS

This expanded section provides additional technical detail to support the description of EcoQuest in the preceding manuscript. It clarifies the functional boundaries of the proposed system, the relationship between learning activities and environmental missions, and the evidence required before claims about platform effectiveness can be made. The additional material is intended to strengthen the technical depth of the paper without presenting planned features or unmeasured outcomes as completed results.

A. Functional Requirements and User Roles

The platform can be organized around three broad user roles: a participant, a content administrator, and a mission reviewer. A participant creates an account, explores learning material, attempts quizzes, selects missions, submits completion information, and reviews personal progress. A content administrator maintains learning modules, mission descriptions, categories, difficulty levels, and reward rules. A mission reviewer examines submissions that require manual validation and records an approval decision with an explanation. These roles should be separated through access control so that ordinary users cannot edit mission definitions, change reward values, or approve their own submissions.

The core functional requirements include account registration and login; profile management; topic-based learning content; quiz delivery and scoring; mission browsing and filtering; submission creation; review-state management; reward calculation; progress persistence; and leaderboard generation. Each requirement should have a corresponding acceptance test. For example, when a user submits a mission, the system should create a submission record with a unique identifier and a status. The score should change only after the configured completion rule is satisfied. If a submission is rejected, the system should retain the decision and should not add the associated points.

B. Proposed Data Entities and Relationships

A normalized data model can reduce duplication and improve traceability. The User entity stores account identity and limited profile information. LearningModule stores the title, topic, lesson text, and references used for educational content. Quiz and QuizQuestion entities store assessment structure and answer keys. Mission stores the activity title, category, instructions, difficulty, safety guidance, evidence requirements, and points available. ProofSubmission connects a user to a mission and stores the evidence reference, submission time, review status, and reviewer feedback. Reward stores badge definitions and eligibility rules. UserProgress can either be calculated from approved submissions or maintained as a carefully synchronized summary.

A submission should reference both the user and the mission through stable identifiers. A mission may have many submissions, while each submission belongs to one user and one mission. Reward eligibility should be derived from approved activity records rather than from a value submitted by the browser. If progress totals are cached for performance, the system should retain the underlying approved records so that totals can be recalculated and audited. This approach makes it easier to detect duplicate submissions, correct mistakes, and explain how a user's score was produced.

C. Mission Design and Completion Rules

A mission should be written as a small, self-contained activity. It should state what the participant is expected to

do, why the activity matters, how long it may take, what evidence is required, and what safety precautions apply. A waste-segregation mission, for example, can ask users to identify common recyclable materials and separate them according to local municipal instructions. A biodiversity observation mission can ask users to photograph a plant from a safe public area without removing or disturbing it. A community clean-up mission should instruct participants not to handle medical waste, broken glass, chemicals, or other hazardous materials.

Mission completion criteria should be specific enough that two reviewers would reach broadly similar decisions. Vague requirements such as 'help the environment' are difficult to verify. Better criteria identify the expected action, the permitted evidence, and the conditions for approval. The platform should also offer alternatives when an activity depends on location, physical ability, or access to resources. A user who cannot attend an outdoor event should still be able to participate through a related learning task or a remote awareness activity.

D. Evidence Verification and Moderation

Evidence submission is a central design risk because a photograph or short video does not automatically prove that an environmental task was completed. A selfie, an unrelated image, a reused photograph, or an image taken outside the stated activity could be submitted unless the workflow defines suitable checks. Capturing evidence directly through a device camera may reduce some forms of gallery reuse, but it cannot guarantee authenticity. Timestamp metadata can also be inaccurate or modified, and location data may create privacy concerns.

A practical first version should use transparent review states: Pending, Approved, Rejected, and Needs More Information. Automated checks may confirm that a file exists, that its format and size are permitted, and that required fields are completed. More meaningful verification may require human review, event-organizer confirmation, or a mission-specific rule. AI image analysis can be explored later as a triage aid, but it should not independently award high-value rewards until its accuracy has been evaluated against a labelled test set. The system should provide an appeal or resubmission path when a user believes a decision is incorrect.

Evidence should be retained only as long as necessary for the stated purpose. Public leaderboard views should not expose original photographs, precise home locations, personal contact details, or other sensitive information by default. The interface should explain what is collected, who can review it, and how long it may be stored. These safeguards are particularly important if the platform is later used by school students or community groups.

E. Gamification and Reward Integrity

Points, badges, and leaderboards should reinforce the environmental learning objective rather than replace it. Points can recognize eligible mission completion, while badges can represent meaningful milestones such as completing a learning pathway, participating in a verified community event, or maintaining a consistent learning habit. A scoring rule should specify whether points are awarded for quiz completion, mission approval, or both. Repeated submissions of the same activity should not create unlimited rewards. The system should also preserve a record of reward changes so that administrators can investigate incorrect awards.

A public leaderboard can make community participation visible, but it may also encourage users to prioritize quantity over quality. To reduce this risk, EcoQuest can provide personal progress views, team-based achievements, and non-competitive milestones alongside ranked scores. The interface should avoid shaming low-ranked participants. A leaderboard should be calculated from eligible stored records and should not be populated with fictional users in a production release. Any demonstration data must be clearly labelled as sample data.

F. Prototype Implementation and Technical Validation

The supplied manuscript identifies HTML and CSS for the interface, Python for backend logic and APIs, and a database for accounts, missions, scores, badges, and progress. These technologies should be confirmed against the final source code before submission to a journal or conference. The prototype screenshots included in the original paper illustrate the home page, learning page, mission page, and leaderboard. Screenshots establish the appearance of those screens at the time they were captured; they do not establish that authentication, database persistence, proof verification, or all navigation controls are connected to a live service.

Before the system is described as fully implemented, the development team should test the complete end-to-end path: create an account, sign in, open a learning module, complete a quiz, select a mission, submit evidence, review the submission, award points, sign out, sign in again, and confirm that the approved progress remains available. Negative tests should include invalid credentials, missing evidence, unsupported file types, duplicate submissions, rejected submissions, unauthorized access to another user's data, and attempts to alter scores from the client side. The test report should record the build version, test environment, expected result, actual result, and defect status.

G. Evaluation Framework

A complete evaluation should separate four questions: does the software work, can users operate it, does it support learning, and does it lead to verified environmental participation? Functional testing can report the proportion of predefined test cases that pass and the number of unresolved defects. Usability testing can measure task completion rate, time on task, navigation errors, and a standardized questionnaire score. Learning evaluation can compare pre-test and post-test knowledge scores and, where possible, include a delayed assessment to examine retention. Engagement evaluation can report repeat visits, mission starts, approved completions, and continued participation over a defined period.

Environmental impact should be measured with units that match the activity. Examples include kilograms of waste collected, number of items correctly sorted, volunteer hours confirmed by an organizer, or saplings surviving after a stated follow-up period. Counts of app users, points, or submitted photographs are not equivalent to environmental impact. Every reported measure should identify its source, collection period, verification method, and limitations. If an impact value is estimated rather than directly measured, it must be labelled as an estimate and the calculation method should be explained.

For a pilot study, the team can recruit a small group of participants, obtain informed consent, and ask them to complete a set of representative tasks. The study should record baseline familiarity with environmental topics, task completion, and user feedback. If learning improvement is a research claim, a pre-test and post-test should be used; if sustained behaviour is a claim, follow-up measurement is required. A control or comparison group would strengthen causal interpretation. The sample size, participant characteristics, study duration, questionnaire items, and analysis method should be reported transparently.

H. Risks, Limitations, and Mitigation

The main risks include false or misleading evidence, duplicate submissions, reward manipulation, privacy exposure, unsafe mission instructions, low-quality learning content, and low repeat participation. These risks can be reduced through mission-specific criteria, server-side reward calculation, access controls, moderation states, limited evidence retention, content review, and safety guidance. The platform should not encourage users to enter restricted areas, handle hazardous waste, disturb wildlife, or undertake activities beyond their ability.

The present project materials do not include a completed user study, validated AI verification model, measured environmental outcomes, or a documented production security audit. These are limitations of the evidence currently available, not proof that the platform cannot eventually support these capabilities. The paper should be updated after implementation and testing so that planned features, demonstrated features, and experimentally evaluated outcomes are clearly distinguished.



Fig. 6. Illustrative environmental activities community litter collection, waste segregation, and sapling planting. AI-generated conceptual image; it does not depict EcoQuest users or document project results.

I. Future Development Roadmap

The recommended development sequence is to stabilize the core workflow before introducing advanced features. First, complete and test account access, learning modules, missions, submission records, reward rules, and persistent progress. Second, conduct usability testing and revise confusing instructions or navigation. Third, introduce a moderated community pilot with clear mission-safety guidance and transparent evidence handling. Fourth, evaluate learning outcomes and verified participation using defined metrics. Only after these stages should the team consider AI-assisted recommendations, automated evidence triage, location-aware missions, offline submission, or a three-dimensional map of local environmental activity. This sequence reduces the risk of adding technically complex features before the basic user journey is reliable.

V. DISCUSSION

EcoQuest's design draws on research about gamified environmental learning and on the complementary functions of existing platforms. Its intended contribution is the integration of learning content, quests, rewards, and progress tracking in a single workflow. This integration may make participation easier to follow, but its actual value depends on the quality of learning content, the relevance of quests, and whether users continue participating beyond initial use.

The main limitation is that the proposed benefits have not yet been validated through controlled testing or a

sufficiently sized user study. The current materials also do not establish the accuracy of AI verification, the effectiveness of location-based activities, or the usability of advanced 3D exploration. Future evaluation should measure task completion, usability, repeat participation, and learning outcomes. Environmental actions should be designed responsibly, with safety guidance and clear rules for acceptable evidence.

VI. CONCLUSION

This paper presented EcoQuest, a proposed gamified web platform intended to connect environmental education with quests, quizzes, rewards, and progress tracking. The literature survey indicates that existing services provide useful but distinct approaches to litter tracking, sustainable habits, community challenges, and biodiversity observations. EcoQuest's proposed contribution is to combine learning and participation in a single experience.

Future work includes completing and testing the core prototype, conducting usability and learning evaluations, and then considering AI-assisted quest recommendations, location-based challenges, activity verification, and richer 3D ecosystem exploration. These extensions should be reported as implemented only after development and testing are complete.

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Author Biographies

Vijender Reddy, D. Revanth Varma, J. Toshan, and K.M.N. Srinith are undergraduate students in the Department of Computer Science and Engineering at Hyderabad Institute of Technology and Management. Their project work focuses on the design of a gamified web platform for environmental learning, quests, progress tracking, and community participation.