Gamified Environmental Education Platform

**Abstract**

Environmental education is often limited to textbook-based instruction, offering little scope for practical application or long-term behavioural change. This project addresses that gap through a gamified digital platform built on the MERN stack, designed to make learning interactive, experiential, and solution-driven. The system features three modes: practice quizzes, game levels with AI-evaluated challenges, and a *Solve Section* where learners tackle real-world problem statements from NGOs and government agencies. Gamification elements—points, badges, and leaderboards—motivate continuous engagement, while AI feedback supports reflective learning. By aligning with the **National Education Policy (NEP) 2020** and the **Sustainable Development Goals (SDGs)**, the platform fosters critical thinking, sustainable habits, and ecological citizenship among learners.

**Introduction**

The world, including India, is experiencing rapid development; however, effective solutions to environmental challenges remain elusive.

Rapid industrialization and the pursuit of progress have contributed to significant environmental issues, including global warming, the greenhouse effect, acid rain, and deforestation. According to the **IPCC (2023)**, global average temperatures have already risen by **1.1°C above pre-industrial levels**, resulting in severe climate impacts such as floods, droughts, and biodiversity loss. The **UNEP (2022)** reports that approximately **1 million species are at risk of extinction** due to human activities. Air pollution is responsible for **7 million premature deaths annually worldwide** (WHO, 2021). In 2024, India ranks fif**th** globally for the most polluted air, with six of the ten most polluted cities located in the country. Environmental damage in India costs about **5.7% of its GDP** annually, which is approximately US$80 billion or Rs 3.75 trillion, including costs from outdoor and indoor air pollution, lack of clean water, and inadequate sanitation. The WHO recommends annual PM2.5 levels not exceeding **5 µg/m³**, yet many Indian cities remain well above this threshold. Despite gradual improvements, India continues to exceed safe environmental limits.

This issue arises from insufficient exposure to environmental education. A UNESCO global survey (2021) found that while **91% of students express concern about climate change**, fewer than **50% feel they are taught adequately about it in school curricula**.

UNESCO's review indicates that only **21 out of 100 countries** fully integrate climate education into their national curricula.

The national curriculum contains lessons that are considered overly traditional and theoretical, and these have been subject to significant criticism. According to the same CSE youth survey, while 85% of students report studying climate change in school, only 35% believe the textbooks and instructional materials are adequate. Many students acknowledge the inclusion of environmental education in their schooling, but note considerable variation in depth and quality. A gap persists between students' expectations for environmental education and the content delivered, particularly regarding the ability to empower students to take meaningful action or comprehend policy and scientific mechanisms.

**Problem Statement**

There is a significant gap in environmental education for students. The current curriculum is out of date and ineffective in terms of student engagement. There is currently a new trend in education that involves gamification. According to studies, gamification increases positive behavioural outcomes (such as sustainable habits) by 23% when compared to normal teaching approaches. A 2021 study in the Sustainability Journal found that gamified eco-challenges (such as recycling competitions) significantly enhanced students' sustainable practices in colleges. 67% of students believe gamified courses are more inspiring than traditional learning (eLearning Industry survey, 2022). Since there is a wave of gamification in eLearning, Gamified environmental education would provide sufficient knowledge and interest in the subject, allowing people to engage in environmentally friendly behaviours.

**Motivation**

Observing the ongoing environmental changes and their potential impacts, I developed a keen interest in exploring environmental education. However, I found that the existing curriculum primarily emphasizes theoretical concepts, many of which are repetitive from earlier stages of education and often fail to sustain engagement. This led me to consider alternative approaches to learning. Upon exploring gamified education, I realized that while the approach holds significant potential, there are limited projects that align with these requirements. Consequently, I decided to design and develop a website that integrates gamification into environmental education, aiming to provide comprehensive knowledge in an engaging and interactive manner.

**Contribution**

This paper presents the design and implementation of a website that delivers gamified environmental education, intended not only for students but also for a broader audience interested in learning about environmental issues. The platform incorporates interactive games, problem-solving activities, and practical exercises to enhance engagement and deepen understanding.

Key contributions include:

* Gamified Environmental Education
* AI-Assisted Evaluation to assess the solutions given by the user
* Motivation through Rewards with titles, badges and points
* Real-World Integration with stating environmental problems given by NGOS and Government.

**Organisation:**

The structure of this paper is organized as follows:

 Section 2 provides a review of related work and existing approaches.

 Section 3 outlines the proposed methodology, including system architecture, data acquisition, processing, and visualization.

 Section 4 discusses the results along with illustrative use cases. Finally, Section 5 summarizes the key findings and highlights potential directions for future research and development.

**Related Work:**

Existing initiatives in gamified learning and sustainability awareness—such as EcoLearn, GreenQuest, and Seppo—demonstrate the potential of interactive education but often lack integration with real-world problem-solving or advanced assessment mechanisms. Moreover, very few platforms actively connect students with authentic ecological challenges posed by NGOs or government bodies, leaving a critical gap between classroom knowledge and practical application. *Our project* addresses this gap byintroducing a gamified web platform that not only engages learners through levels, quizzes, and badges but also empowers them to contribute solutions to real environmental issues. Through its AI-assisted evaluation system and reward-based progression, the platform combines interactive education with actionable impact, thereby aligning with the experiential learning goals of NEP 2020 and the sustainability objectives of the UN SDGs.

**System Overview:**

**User access:**

Each person is going to have different things they are able to do in the website which will explained later.

The platform will accommodate multiple categories of user accounts, classified into three distinct types:

1. **Learners**
2. **Institutions**
3. **Organizations**

Each user type will be associated with specific roles, functionalities, and permissions within the system. The scope of these capabilities will be outlined and elaborated upon in subsequent sections.

Learning:

1. **Practice:** This mode consists of multiple-choice questions (MCQs) designed to reinforce conceptual understanding. Correct responses are rewarded with points, thereby fostering learner engagement and self-assessment.
2. **Game Levels:** In this mode, learners encounter obstacles that can be removed by providing correct responses. Each response is evaluated by an artificial intelligence (AI) system, which not only assigns points based on the accuracy and quality of the answer but also delivers constructive feedback. Furthermore, the AI suggests improved alternatives or approaches to the problem, thereby supporting reflective learning and enhancing problem-solving skills.
3. **Solve Section:** This mode presents real-world problem statements obtained from non-governmental organizations (NGOs) and governmental agencies. It enables learners to apply theoretical knowledge to practical contexts, thereby bridging the gap between academic learning and societal problem-solving.

**User abilities:**

**1. Learners**

Learner accounts are designated for individuals who have enrolled to pursue environmental education through the platform. These users are granted access to interactive learning features, including participation in gamified activities and engagement with the *Solve Section*. Learners are rewarded based on their level of participation and performance, thereby encouraging active involvement and sustained learning outcomes.

**2. Institutions**

Institutional accounts are intended for schoolteachers and administrators who oversee and facilitate the learning process. These users are provided with a dedicated leaderboard system that reflects institutional performance and engagement. In addition, they receive structured practice materials designed to support classroom instruction. Based on their implementation and participation, institutions are assigned evaluative grades, which serve both as a measure of effectiveness and as a motivational tool for fostering high-quality educational delivery.

**3. Organizations**

Organizational accounts are designated for governmental bodies and non-governmental organizations (NGOs) engaged in environmental education initiatives. These users are empowered to submit problem statements that reflect real-world environmental challenges. Learners then engage with these problem statements by proposing solutions. The most effective and innovative responses are subsequently identified and forwarded to the respective organization, thereby fostering collaboration between learners and institutions while addressing authentic societal and environmental issues.

**Reward System:**

**Seeds (Points):**

* Awarded for correct answers in *Practice* and *Game Levels*.
* Bonus seeds for submitting solutions in the *Solve Section*.
* Acts as the core currency of the platform.

**Badges & Titles:**

* Earned when users complete modules, levels, or achieve milestones.
* Examples: Suddhi, *Pavan*, *Varuna*.
* Builds a sense of achievement and recognition.

**Leaderboard Rankings:**

* Displays top performers at school, city, and national level.
* Promotes healthy competition and motivates consistent participation.
* Can be filtered by *individuals, schools, or teams*.

**Competitions & Rewards:**

* Seasonal or monthly contests (powered by NGO/Govt challenges).
* Encourages long-term retention beyond just classroom use.

Technical Approach

The proposed system is developed using the MERN (MongoDB, Express.js, React, Node.js) technology stack, which provides a scalable, efficient, and modular architecture for web-based applications.

* **Frontend Development:** The user interface, including the interactive website and game environment, is implemented using **HTML**, **CSS**, and **JavaScript** (framework). This ensures responsive design, dynamic interactivity, and a seamless user experience.
* **Backend Development:** The server-side logic is managed through **Node.js with Express.js**, enabling efficient request handling, secure communication, and robust API integration**.**
* **Database Management: MongoDB** serves as the primary database for storing structured and unstructured data. Key categories of stored information include:
  + **User Data:** Profiles, learning progress, and rewards.
  + **Content Data:** Questions, challenges, and instructional materials.
  + **Submission Data:** Learner answers and AI-generated evaluations.
  + **Gamification Data:** Seeds, badges, and leaderboard rankings.
  + **System Logs & Analytics:** Usage data for monitoring, performance optimization, and research insights.

This architecture supports real-time interaction, adaptive feedback, and secure data management, ensuring a robust foundation for an educational and gamified learning platform.

**How the project addresses the solution:**

**From Theory to Practice**

The platform advances beyond traditional textbook-based instruction by embedding interactive and gamified learning strategies. Learners engage in challenges, quizzes, and eco-actions, thereby developing knowledge through active participation rather than passive content consumption.

**Engagement through Gamification**

The system employs gamification mechanisms such as seeds (points), badges, and leaderboards to enhance motivation. These features foster a sense of achievement and healthy competition, sustaining learner engagement over the long term while reinforcing positive learning behaviours.

**Connecting to Real Issues**

Through the *Solve Section*, the platform integrates authentic problem statements contributed by NGOs and government agencies. By formulating solutions to these real-world challenges, learners not only contextualize their knowledge but also contribute to community development and potential policy outcomes.

**Building Sustainable Habits**

The platform emphasizes the transition from knowledge acquisition to behavioral transformation. Practical eco-tasks—such as tree planting, waste segregation, and energy conservation—enable learners to internalize sustainability practices. This experiential approach further encourages students to influence peers, families, and communities, amplifying environmental impact.

Alignment with NEP 2020 and SDGs

The initiative aligns with the National Education Policy (NEP) 2020, which advocates for experiential and application-based learning in India. Additionally, it contributes directly to the United Nations Sustainable Development Goals (SDGs), particularly *Climate Action (SDG 13)* and *Life on Land (SDG 15)*, by fostering environmental awareness and sustainable practices among youth.

**Potential Impacts of the Project**

**1. Educational Impact**

* **Enhanced Learning Outcomes:** By integrating gamification and real-world challenges, the platform promotes deeper conceptual understanding of environmental education beyond rote memorization.
* **Experiential Learning:** Students gain practical exposure through eco-actions and problem-solving tasks, aligning with 21st-century skills such as critical thinking, collaboration, and innovation.

**2. Social Impact**

* **Community Engagement:** Learners influence peers, families, and communities through sustainable practices, creating ripple effects that extend beyond the classroom.
* **Collaboration with NGOs and Government:** By solving authentic problem statements, learners contribute to socially relevant initiatives, potentially informing local policies and community programs.

**3. Environmental Impact**

* **Behavioural Transformation:** Eco-tasks such as waste segregation, energy conservation, and tree plantation cultivate long-term sustainable habits among learners.
* **Collective Action:** Large-scale participation in environmental practices contributes directly to climate action and biodiversity conservation.

**4. Policy and Institutional Impact**

* **Alignment with NEP 2020:** Supports the Indian education system’s shift toward experiential and competency-based learning**.**
* **Support for SDGs:** Advances global sustainability objectives, particularly SDG 4 (*Quality Education*), SDG 13 (*Climate Action*), and SDG 15 (*Life on Land*).
* **Institutional Benchmarking:** Leaderboards and grading systems create accountability structures for schools and organizations, motivating continuous improvement.

**5. Technological Impact**

* **Scalable Digital Infrastructure:** The MERN-based architecture ensures scalability, adaptability, and potential replication across diverse educational contexts.
* **AI-driven Feedback:** Personalized evaluations and constructive suggestions from AI enhance adaptive learning and continuous improvement for students.

**Conclusion**

This project offers an innovative approach to environmental education by combining gamification, experiential learning, and real-world problem-solving. Through interactive challenges, AI-driven feedback, and eco-actions, it encourages both knowledge acquisition and sustainable behaviour. By involving learners, institutions, NGOs, and government agencies, the platform aligns with NEP 2020 and the SDGs, while leveraging the MERN stack for scalability. Ultimately, it equips students to become environmentally responsible citizens capable of driving meaningful change.