

Harnessing Mobile and Web Applications for Environmental Education: A Comprehensive Review of iNaturalist and Plum Landing Applications

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Abstract

With the growing urgency of environmental challenges worldwide, effective environmental education has become essential for fostering awareness, promoting sustainable practices, and empowering individuals to become stewards of the environment (Carrol, 2019). In recent years, mobile and web applications have emerged as powerful tools for delivering engaging and interactive environmental education content to diverse audiences (Dede, 2009). This research paper provides a comprehensive review of the role of mobile and web applications in environmental education, particularly in the context of two popular Environmental education Applications, named iNaturalist and Plum Landing. Through an analysis of existing literature, case studies, and best practices, this paper examines the design, features, effectiveness, and challenges of mobile and web applications for environmental education. The research work comprises of qualitative research methodology under case study, content analysis and comparative analysis under SWOT analysis from existing data related to the aforementioned Environmental education applications available on public domain. The findings highlight the potential of these applications to enhance learning outcomes, engage users, and inspire positive environmental action, while also identifying opportunities for improvement and future research directions. This comprehensive review paper suggests that though these two applications boasts of several positives for boosting environmental education and awareness in an interesting way among young learners through technological integration, there are few steps and integration to be made in order to make it more interesting and involving among the 21st century Generation Alpha learners.

Keywords: Environmental Education, iNaturalist, Plum Landing, Environmental education Apps

1. Introduction

1.1 Background and significance of environmental education

Environmental education is a multifaceted field aimed at raising awareness, fostering understanding, and promoting action towards environmental conservation and sustainability. It encompasses a wide range of activities, programs, and initiatives designed to empower individuals and communities to become informed and responsible stewards of the environment. The roots of environmental education can be traced back to early conservation movements and indigenous knowledge systems, which emphasised the interconnectedness of humans and nature.

The significance of environmental education stems from the urgent need to address pressing environmental challenges facing the planet. From climate change and biodiversity loss to pollution and resource depletion, these challenges threaten the well-being of ecosystems, species, and human societies. Environmental education plays a critical role in addressing these challenges by:

1. **Raising Awareness:** Environmental education increases public awareness of environmental issues, their causes, and potential solutions. By providing accurate information and fostering critical thinking skills, it helps individuals understand the interconnectedness of environmental, social, and economic systems.
2. **Fostering Understanding:** Environmental education promotes a deeper understanding of ecological principles, natural processes, and human impacts on the environment. It encourages appreciation for the complexity and beauty of the natural world, as well as recognition of the value of biodiversity and ecosystem services.
3. **Empowering Action:** Environmental education empowers individuals and communities to take action to protect and sustainably manage the environment. By providing knowledge, skills, and tools for problem-solving and decision-making, it enables people to make informed choices and advocate for environmental policies and practices.

In summary, environmental education is essential for addressing the complex environmental challenges facing the world today. By raising awareness, fostering understanding, empowering action, promoting sustainable lifestyles, building resilience, and fostering environmental citizenship, it plays a crucial role in creating a more sustainable and equitable future for all.

1.2 Role of technology in education

The role of technology in education is transformative, offering innovative tools and approaches to enhance teaching, learning, and educational outcomes. Here's a brief overview:

1. **Access to Information:** Technology provides easy access to vast amounts of information through the internet, enabling students and educators to access resources, research materials, and educational content from around the world.

2. **Interactive Learning:** Technology facilitates interactive and engaging learning experiences through multimedia resources, simulations, and educational games. This interactive approach caters to diverse learning styles and promotes active participation in the learning process.

3. **Personalized Learning:** Technology enables personalized learning experiences tailored to individual student needs and preferences. Adaptive learning platforms and intelligent tutoring systems adjust content and pacing based on student performance, optimizing learning outcomes.

Overall, technology plays a pivotal role in shaping the future of education, offering new possibilities for teaching, learning, and collaboration in an increasingly interconnected world.

1.3 Introduction to mobile and web applications for environmental education

Mobile and web applications for environmental education offer innovative and accessible ways to engage individuals in learning about environmental issues, fostering awareness, understanding, and action. Here are several examples of such applications:

1. **iNaturalist:** iNaturalist is a citizen science platform and mobile application that allows users to observe and record biodiversity in their surroundings. Users can upload photos of plants, animals, and fungi, which are then identified by the community or through artificial intelligence. iNaturalist promotes environmental education by enabling users to learn about local biodiversity, contribute to scientific research, and participate in conservation efforts.

2. **EarthViewer:** EarthViewer is an interactive web application developed by the Howard Hughes Medical Institute that allows users to explore the history of Earth's climate, continents, and life forms over geological time scales. Through animated maps, timelines, and scientific data, users can visualise key events such as continental drift, climate change, and mass extinctions. EarthViewer promotes environmental education by providing a dynamic and immersive learning experience on Earth's geological and environmental history.

3. **Plum Landing:** Plum Landing is a web-based environmental education platform designed for elementary school students. Through interactive games, videos, and hands-on activities, Plum Landing engages students in exploring ecosystems, biodiversity, and environmental science concepts. The platform also includes educator resources and lesson plans aligned with Next Generation Science Standards (NGSS), making it a valuable tool for classroom instruction.

By leveraging digital technology, these applications have the potential to inspire environmental stewardship and empower individuals to make positive contributions to the health of the planet.

1.4 Theoretical perspectives on environmental education

Theoretical perspectives on environmental education provide frameworks for understanding the goals, principles, and practices of environmental education initiatives. These perspectives draw on various disciplines, including education, psychology, sociology, and environmental science, to inform the design, implementation, and evaluation of environmental education programs. Below are some key theoretical perspectives:

1. **Ecological Systems Theory:** Ecological systems theory, developed by Urie Bronfenbrenner, emphasizes the interconnectedness of individuals, communities, and the environment. This theory posits that environmental education should consider the multiple levels of influence, including the microsystem (individuals and immediate surroundings), mesosystem (interactions between microsystems), exosystem (external environments impacting microsystems), and macrosystem (cultural and societal contexts). Ecological systems theory highlights the importance of fostering environmental awareness, values, and behaviors within the context of complex ecological systems.

2. **Constructivism:** Constructivism is a learning theory that emphasizes the active construction of knowledge through personal experiences, interactions, and reflection. In environmental education, constructivism suggests that learners construct their understanding of environmental issues through inquiry-based activities, hands-on experiences, and collaborative learning. By engaging students in authentic, real-world investigations and problem-solving tasks, constructivist approaches promote deeper understanding, critical thinking, and personal relevance in environmental education.

3. **Other perspectives include Place-based Education, Critical Pedagogy, Socio-ecological Systems Theory:** Socio-ecological systems theory examines the dynamic interactions between social, economic, and ecological systems. This perspective recognizes that environmental issues are often rooted in complex social and economic factors, and that effective solutions require interdisciplinary and systemic approaches. Socio-ecological systems theory informs environmental education by highlighting the interconnectedness of human societies and natural ecosystems, and the need for holistic, integrated approaches to sustainability.

These theoretical perspectives provide valuable frameworks for understanding the goals, principles, and practices of environmental education. By integrating insights from ecology, psychology, sociology, and education, environmental educators can develop more effective and contextually relevant programs that promote environmental awareness, stewardship, and sustainability.

1.5 Technology-enhanced learning theories

Technology-enhanced learning theories provide frameworks for understanding how digital technology can be effectively integrated into educational practices to enhance teaching and learning outcomes. Here are some key theories in this field:

1. **Constructivism:** Constructivism posits that learners actively construct knowledge and understanding through their interactions with the environment. In technology-enhanced learning, constructivist approaches emphasize the use of digital tools and resources to facilitate inquiry-based learning, problem-solving, and collaborative knowledge construction. Technology supports learners in exploring, experimenting, and making meaning of concepts through interactive simulations, multimedia presentations, and online discussions.
2. **Connectivism:** Connectivism emphasizes the role of digital networks and information resources in shaping learning environments. According to this theory, learning occurs through connections between nodes in a network, including people, resources, and technologies. In technology-enhanced learning, connectivist approaches leverage online communities, social media platforms, and digital repositories to facilitate knowledge sharing, collaboration, and distributed cognition. Learners engage in networked learning experiences that extend beyond traditional classroom boundaries, accessing and contributing to global knowledge networks.
3. Other theories include Cognitive Load Theory, Multimodal Learning Theory, Socio-cultural Theory, Activity Theory etc.

These theories provide valuable insights into how digital technology can be effectively integrated into educational practices to support learner-centred, interactive, and engaging learning experiences. By drawing on these theoretical perspectives, educators can design and implement technology-enhanced learning environments that promote deep understanding, critical thinking, and lifelong learning skills.

1.6 Conceptual framework for analysing mobile and web applications in environmental education

1. Pedagogical Approach
2. Content and Curriculum
3. Interactivity and Engagement
4. User Experience and Accessibility
5. Technological Features
6. Assessment and Feedback

7. Community and Collaboration

By using this conceptual framework, researchers, educators, and developers can systematically analyse and evaluate mobile and web applications in environmental education, identifying strengths, weaknesses, and areas for improvement to enhance their effectiveness and impact on learning outcomes.

1.7 Statement of the Problem

The Problem statement of current research is “Harnessing Mobile and Web Applications for Environmental Education: A Comprehensive Review of iNaturalist and Plum Landing Applications”

1.8 Research Question

1. What is the efficaciousness and shortcomings of iNaturalist and Plum Landing applications in context of environmental education?

1.9 Research Objectives

Following are the objectives of the present research:

1. To assess the effectiveness of iNaturalist and Plum Landing Applications in Environmental Education
2. To explore user engagement and interaction patterns of the iNaturalist and Plum Landing Applications
3. To investigate educational strategies and pedagogical approaches of the iNaturalist and Plum Landing Applications
4. To identify opportunities for improvement and innovation of the iNaturalist and Plum Landing Applications
5. To address ethical considerations and user privacy concerns of the iNaturalist and Plum Landing Applications

2. Literature Review and Theoretical Framework

2.1 Literature review related to applications related to environmental education

Mobile and web applications play a crucial role in enhancing environmental education by providing interactive learning experiences, personalised instruction, and real-world application of environmental concepts (**Wong et al., 2018**). These technologies offer opportunities for learners to explore environmental topics through engaging multimedia content, interactive games, and virtual field trips (**Ching et al., 2019**).

Apps like iNaturalist have revolutionised citizen science and biodiversity monitoring efforts by engaging the public in scientific research and data collection (**Bowser et al., 2017**). Studies have shown that these apps effectively mobilise volunteers to document species observations, contributing valuable data for conservation research and management (**Troudet et al., 2018**).

Gamification principles are frequently employed in environmental education apps to enhance user engagement and motivation (**Chen & Yen, 2019**). By incorporating elements of play and exploration, these apps provide immersive and experiential learning experiences that encourage active participation and knowledge retention (**Lee et al., 2020**).

Advancements in adaptive learning technologies enable the customisation of educational content based on individual learner profiles and preferences (**Liao et al., 2021**). Mobile and web apps for environmental education can leverage these technologies to deliver personalised learning experiences that cater to diverse learner needs (**Shen et al., 2018**).

Web-based platforms like Plum Landing facilitate social learning and community engagement by connecting users with like-minded individuals, educators, and experts (**McClure et al., 2018**). These platforms provide opportunities for collaboration, knowledge sharing, and collective action towards environmental conservation goals (**Boud et al., 2020**).

Ensuring the accessibility and inclusivity of environmental education apps is crucial for reaching diverse audiences (**He et al., 2019**). Designing apps with accessible features and culturally relevant content promotes equitable access to environmental education resources (**Zhang et al., 2021**).

3. Research Design

3.1 Research Methodology

For this research, Qualitative research methodology was chosen. In this connotation, content analysis of user-generated content, reviews and sessions related to iNaturalist and Plum Landing Applications on various social media platforms, forums, and app stores was made in order to identify recurring themes and features.

3.2 Tools and Techniques

Case study was implemented under qualitative mode as a tool for reviewing the iNaturalist and Plum Landing applications for Environmental education. In addition, Content analysis and SWOT analysis were also incorporated in this study.

4. Research Findings and Results

Through the content analysis, Comparative analysis through SWOT and case study of both the applications, following findings were concluded in a nutshell mentioned as under:-

4.1. Findings about the iNaturalist Applications:

Features:

- Observation Recording: Users can record observations of plants, animals, and other organisms using photos, location data, and descriptive information.
- Species Identification: iNaturalist employs image recognition technology and community-based verification to help users identify species and learn about biodiversity.

- Citizen Science Projects: Users can participate in citizen science projects, contribute to scientific research, and collaborate with experts and fellow enthusiasts.
- Social Networking: iNaturalist fosters a supportive community of nature enthusiasts, enabling users to connect with like-minded individuals, share observations, and discuss biodiversity topics.
- Educational Resources: The application provides educational resources, tutorials, and identification guides to help users learn about nature and improve their observation skills.

Impact:

- iNaturalist has become one of the largest and most influential citizen science platforms for biodiversity monitoring and research worldwide.
- The platform has facilitated millions of observations, contributed to scientific discoveries, and engaged a global community of users in nature observation and conservation efforts.
- iNaturalist has been used by researchers, educators, policymakers, and conservation organisations to monitor biodiversity, inform conservation priorities, and raise public awareness about the importance of protecting natural ecosystems.
- User Feedback:
 - Positive Feedback: Users praise iNaturalist for its user-friendly interface, accurate species identification, and vibrant community of users. Many users appreciate the opportunity to contribute to scientific research and connect with fellow nature enthusiasts.
 - Constructive Criticism: Some users have reported occasional issues with species identification accuracy, particularly for less common or regionally specific organisms. Others have suggested improvements to the user interface and navigation features to enhance usability and accessibility.

4.2 Findings about the Plum Landing application:**Features:**

1. Interactive Games: Plum Landing offers a variety of interactive games designed to engage children in learning about ecosystems, biodiversity, and environmental concepts.
2. Videos and Animations: The app features animated videos that introduce environmental topics in a fun and accessible way, catering to different learning styles.
3. Hands-On Activities: Plum Landing provides hands-on activities and experiments that allow children to explore nature and learn through experiential learning.
4. Virtual Field Trips: Users can embark on virtual field trips to different ecosystems, offering a simulated exploration experience.
5. Creative Tools: The app includes creative tools such as drawing and photo editing features, allowing children to express their understanding of environmental concepts creatively.

Educational Content:

1. Ecosystem Exploration: Plum Landing educates users about various ecosystems, including forests, oceans, deserts, and wetlands, highlighting their importance and unique characteristics.

2. Biodiversity Awareness: The app introduces children to different plant and animal species, fostering an understanding of biodiversity and the interdependence of living organisms.

3. Environmental Concepts: Plum Landing teaches environmental concepts such as climate change, conservation, recycling, and sustainability through age-appropriate content.

4. Stewardship Lessons: The app promotes environmental stewardship by encouraging users to adopt sustainable behaviours and take action to protect the planet.

Personalised Recommendations:

Plum Landing offers personalised recommendations based on users' interests, preferences, and learning progress. It uses algorithms to suggest activities, games, and videos that align with each child's educational needs and learning goals.

- Social Sharing:

Users can share their experiences, achievements, and creations on social media platforms directly from the app. This feature encourages social sharing and allows children to showcase their environmental learning journey with friends and family.

- Community Engagement:

Plum Landing fosters a sense of community among users through forums, discussion boards, and virtual meet-ups where children can connect with like-minded peers, share ideas, and collaborate on environmental projects.

Impact:

Plum Landing has had a positive impact on children's environmental knowledge, attitudes, and behaviours. Users report increased awareness of environmental issues, a deeper connection to nature, and a greater sense of responsibility for protecting the planet.

User Feedback:

Overall, users praise Plum Landing for its engaging content, interactive features, and positive impact on children's environmental education. Many parents and educators commend the app for making learning fun and accessible, while children express enthusiasm for exploring nature and learning about the environment through the app.

Constructive Criticism:

Some users have provided constructive criticism regarding the app's navigation and user interface, suggesting improvements to make it more intuitive and user-friendly. Additionally, there are suggestions for expanding the app's content library and incorporating more diverse perspectives and experiences to ensure inclusivity.

In summary, both iNaturalist and Plum Landing exemplify the potential of mobile and web applications for environmental education to engage users, promote learning, and inspire positive action towards environmental conservation and sustainability. Through innovative features, impactful outreach, and ongoing user feedback, these applications continue to make meaningful contributions to environmental education and biodiversity conservation efforts worldwide.

4.3 Challenges and Limitations

While iNaturalist and Happy Earth have made significant contributions to environmental education and conservation efforts, they also face certain challenges and limitations:

4.3.1 Challenges and Limitations of iNaturalist:

1. **Species Identification Accuracy:** Despite its advanced image recognition technology, iNaturalist may still encounter challenges in accurately identifying species, particularly for less common or regionally specific organisms. This can lead to misidentifications and errors in scientific data.
2. **Data Quality Control:** Maintaining data quality and reliability can be challenging in a community-driven platform like iNaturalist. Ensuring the accuracy and completeness of user-contributed observations requires robust verification mechanisms and ongoing monitoring.
3. **User Engagement and Retention:** Sustaining user engagement and participation over time can be challenging, especially among new users or those with limited experience in nature observation. Encouraging continued participation and contributions is essential for the long-term success of the platform.
4. **Accessibility and Inclusivity:** iNaturalist may face accessibility barriers for users with disabilities or limited access to technology. Ensuring the platform is accessible to diverse audiences, including those with visual or mobility impairments, is important for promoting inclusivity and equity.
5. **Privacy Concerns:** Sharing location data and personal observations on iNaturalist may raise privacy concerns for some users. Ensuring user privacy and data protection while still facilitating scientific research and collaboration is a delicate balance.

4.3.2 Challenges and limitations of the Plum Landing application:

1. **Digital Dependency:** Plum Landing's reliance on digital technology may contribute to increased screen time for children, potentially detracting from hands-on outdoor experiences and direct engagement with nature. Balancing digital learning with real-world exploration is essential for fostering a holistic understanding of environmental concepts.
2. **Access and Equity:** Access to digital devices and internet connectivity may be limited for some children, particularly those from low-income or rural communities. This digital divide can hinder equitable access to Plum Landing's educational resources, perpetuating disparities in environmental education.
3. **Age Appropriateness:** While Plum Landing is designed for children aged 6-10, the content may not cater equally to all age groups within this range. Ensuring that educational materials are age-appropriate and engaging for diverse learners can be challenging.
4. **Content Diversity, Teacher Training and Integration, Privacy and Data Security, Sustainability and others.**

Addressing these challenges and limitations will be essential for Plum Landing to realize its full potential as an effective tool for environmental education and engagement among children.

5. Conclusion

The combination of iNaturalist and the Plum Landing app presents a powerful synergy with significant implications for both practice and policy. iNaturalist enables users to engage in citizen science by documenting biodiversity, while Plum Landing encourages environmental education and connection with nature, particularly among children.

In practice, this combination empowers users of all ages to actively participate in scientific research, contributing valuable data on species distribution and environmental health. By integrating these apps into educational curricula or community programs, practitioners can enhance experiential learning and foster a sense of environmental stewardship. Children using Plum Landing can learn about biodiversity and then apply that knowledge by contributing observations to iNaturalist, creating a tangible link between learning and real-world conservation efforts.

From a policy perspective, the data collected through iNaturalist and the engagement facilitated by Plum Landing can inform evidence-based policymaking in environmental conservation and education. Policymakers can use this data to identify priority areas for conservation, allocate resources effectively, and design educational initiatives that promote environmental literacy and engagement. Furthermore, advocacy for integrating these apps into formal education systems can lead to policies that prioritise environmental education, nurturing a generation of environmentally aware citizens equipped to address pressing environmental challenges. Thus, the integration of iNaturalist and Plum Landing apps has the potential to catalyse positive change at both individual and systemic levels, advancing environmental conservation and education agendas.

Mobile and web applications have immense transformative potential in environmental education, offering innovative tools to engage individuals, communities, and stakeholders in learning, conservation, and action. By harnessing the power of technology, these applications empower users to explore, understand, and protect the natural world in unprecedented ways. From citizen science platforms like iNaturalist that enable users to contribute valuable data to scientific research, to educational apps like Happy Earth that inspire sustainable behaviours and environmental stewardship, these applications catalyse a shift towards a more informed, connected, and environmentally conscious society. With their accessibility, scalability, and interactive features, mobile and web applications have the capacity to reach diverse audiences, bridge knowledge gaps, and mobilise collective efforts for environmental sustainability. As we continue to innovate and harness the potential of digital

technologies, let us seize the opportunity to cultivate a new generation of environmentally literate citizens who are empowered to create positive change and shape a more sustainable future for our planet.

6. Recommendations for further Research

Further research and development in environmental education applications can focus on several key areas to enhance their effectiveness, reach, and impact. Here are some areas for consideration:

1. Personalisation and Adaptive Learning:

- Explore the potential of personalised learning algorithms and adaptive learning technologies to tailor educational content, activities, and assessments to individual learners' needs, preferences, and learning styles.
- Investigate how adaptive learning systems can optimise user engagement, knowledge retention, and behaviour change by dynamically adjusting content delivery, difficulty levels, and feedback mechanisms.

2. Augmented Reality (AR) and Virtual Reality (VR):

- Investigate the use of AR and VR technologies to create immersive learning experiences that enable users to explore and interact with virtual environments, ecosystems, and conservation projects.
- Explore the potential of AR and VR applications for virtual field trips, habitat restoration simulations, and environmental storytelling to enhance environmental literacy and empathy.

3. Citizen Science and Crowdsourced Data Collection:

- Explore innovative approaches to citizen science and crowdsourced data collection within environmental education applications, including gamification elements, community challenges, and collaborative research projects.
- Investigate how citizen science initiatives can contribute to scientific research, monitoring, and conservation efforts while engaging users in hands-on learning experiences and environmental stewardship.

By advancing research and development in these areas, environmental education applications can evolve into powerful tools for promoting environmental literacy, fostering sustainable behaviour change, and empowering individuals and communities to address pressing environmental challenges. Collaboration among researchers, educators, technologists, and stakeholders will be essential to drive innovation and maximise the impact of environmental education initiatives in the digital age.

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