Revitalization of Educational Information Media in Batur UNESCO Global Geopark Using QR-Code and Web-Based Augmented Reality

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Abstract.

Batur UNESCO Global Geopark in Bali represents a significant natural and cultural heritage area with high educational value. However, the existing information delivery system primarily relies on static information boards, which are less effective in engaging visitors, particularly younger generations accustomed to digital technology. This community service project aims to revitalize educational information media in Batur Geopark through the integration of QR-code technology and Web-based Augmented Reality (WebAR). The implementation method includes needs analysis with geopark stakeholders, design of QR-code-based educational media, development of 3D models representing key geosite elements (Mount Batur, Kintamani dog, and Trunyan village), and integration into a WebAR platform accessible via smartphones. The system was evaluated through user testing involving students, tourists, and local communities to assess usability, accessibility, and learning effectiveness. The results demonstrate that the proposed system enhances user engagement and improves understanding of geological, ecological, and cultural information. The combination of QR-code and interactive 3D visualization provides a more immersive and flexible learning experience compared to conventional methods. Additionally, the approach supports environmentally friendly information dissemination and promotes sustainable geotourism education. This study highlights the potential of digital technology integration in strengthening educational functions within geopark areas and serves as a model for similar implementations in other geotourism destinations.

Keywords: *QR-code; WebAR; Geopark Education; Interactive Learning; Community Service and Batur Geopark.*

I. INTRODUCTION

Batur UNESCO Global Geopark, located in Bangli Regency, Bali, Indonesia, is a globally recognized area that integrates geological, ecological, and cultural heritage into a sustainable tourism and educational environment. The geopark features unique geological formations such as the Batur caldera and volcanic lake, alongside rich biodiversity and local cultural traditions. These characteristics make Batur Geopark a strategic site for educational tourism and environmental awareness development. Despite its significant potential, the current information delivery system within the geopark remains limited. Most educational content is presented through static information boards, which are often outdated, less interactive, and insufficient to engage modern visitors, particularly younger generations who are highly familiar with digital technology. As a result, the effectiveness of knowledge transfer related to geological processes, ecological values, and cultural heritage is not optimal. The rapid advancement of digital technology has opened new opportunities for enhancing learning experiences in tourism environments. Technologies such as Quick Response (QR) codes and Augmented Reality (AR) have been widely adopted in educational contexts to provide interactive, accessible, and engaging content. Previous studies have shown that QR-code-based systems can improve access to information and increase user participation in tourism and heritage sites [1]. Additionally, AR technology enables users to visualize complex objects and environments in three-dimensional (3D) forms, significantly enhancing understanding and engagement [2]. In the context of geotourism, integrating QR-code and AR technologies offers a promising approach to transform conventional information systems into interactive digital learning platforms.

However, the application of such technologies in geopark environments, particularly in Batur Geopark, remains limited. Furthermore, the involvement of local communities in developing educational content is still not optimally implemented, despite their important role in preserving and conveying local knowledge and cultural values. To address these challenges, this community service project proposes the development of an interactive educational information system based on QR-code integration and Web-based

Augmented Reality (WebAR). The system is designed to provide digital access to 3D models, multimedia content, and narrative explanations related to key elements of Batur Geopark, including Mount Batur, Kintamani dog, and Trunyan village. The objectives of this study are: (1) to develop interactive educational media using QR-code technology that is accessible and engaging for visitors; and (2) to integrate digital content, including 3D models and augmented reality visualization, to enhance visitors' understanding of geological, ecological, and cultural aspects of the geopark. This work is expected to contribute to the digital transformation of geotourism education and serve as a model for implementing technology-based learning in other geopark areas.

II. METHODS

This study adopts a community service approach combined with a technology-driven development framework to design and implement interactive educational media in Batur UNESCO Global Geopark. The methodology consists of six main stages: needs analysis, system design, 3D content development, community involvement, system testing and evaluation, and implementation.

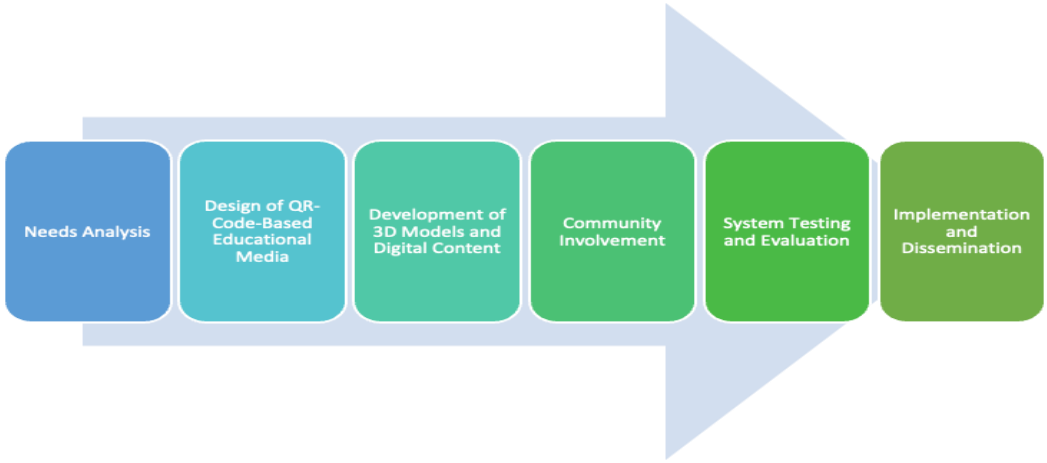

Fig 1. Methods

2.1 Needs Analysis

The initial stage involved field observations and discussions with geopark stakeholders, including management staff, educators, and local community representatives. This stage aimed to identify existing problems, user needs, and strategic locations for deploying educational media. The analysis revealed that current information delivery relies heavily on static boards, lacks interactivity, and does not fully utilize digital technology to enhance visitor engagement.

2.2 Design of QR-Code-Based Educational Media

Based on the identified needs, an interactive educational media system was designed using QR-code technology. Each information point within the geopark is equipped with a unique QR-code that can be scanned using a smartphone. The QR-code directs users to digital content hosted on a web-based platform, ensuring accessibility without requiring additional application installation. The design process considered usability, visual clarity, and accessibility to ensure that the system can be used by a wide range of visitors, including students, tourists, and local communities.

2.3 Development of 3D Models and Digital Content

To enhance the learning experience, several 3D models were developed representing key elements of Batur Geopark, including Mount Batur, the Kintamani dog, and Trunyan village. The models were created using Blender software, with references from topographic data and field documentation to ensure accuracy. The 3D models were integrated into a Web-based Augmented Reality (WebAR) system, allowing users to interact with the models directly through their mobile browsers. Additional digital content, including descriptive narratives, images, and educational explanations, was embedded to provide comprehensive information about geological formations, ecological features, and cultural heritage.

2.4 Community Involvement

Local community members and geopark managers were actively involved in the development process, particularly in providing contextual narratives and local knowledge. This participatory approach ensures that the educational content reflects authentic cultural perspectives and promotes community engagement in geotourism development.

2.5 System Testing and Evaluation

The developed system was tested with a group of users consisting of students, tourists, and local residents. The evaluation focused on usability, accessibility, visual attractiveness, and user understanding of the presented information. Data were collected through direct observation, questionnaires, and informal interviews. The evaluation results were used to assess system effectiveness and identify areas for improvement.

2.6 Implementation and Dissemination

After testing and refinement, the QR-code-based educational media were deployed at selected strategic locations within Batur Geopark, such as the geopark museum, lake area, and cultural sites. The results of the project were disseminated through institutional websites, social media platforms, and reports to stakeholders, ensuring broader accessibility and potential scalability of the system.

III. RESULT AND DISCUSSION

3.1 Needs Analysis Results

The needs analysis revealed several critical issues in the current educational information system at Batur UNESCO Global Geopark. Most information is delivered through static boards that are outdated, less visually engaging, and lack interactivity. This limitation reduces visitors' interest and understanding, particularly among younger audiences who are accustomed to digital and interactive media. Stakeholders, including geopark management and local communities, expressed the need for an educational system that is interactive, easily accessible, and capable of integrating multimedia content. Additionally, there is a strong expectation that the system should support local cultural representation and be sustainable for long-term use. These findings highlight the importance of integrating digital technology into geotourism education.

Fig 2. Needs Analysis

3.2 Development of 3D Models and Digital Content

The project successfully developed three main 3D models representing key aspects of Batur Geopark: Mount Batur (geological aspect), Kintamani dog (ecological and cultural identity), and Trunyan village (socio-cultural heritage). These models were designed to provide visual and interactive representations of complex information that cannot be effectively conveyed through traditional media. The Mount Batur model illustrates the caldera structure, volcanic processes, and lava flow patterns, enabling

users to better understand geological phenomena. The Kintamani dog model highlights local biodiversity and serves as an engaging educational medium, especially for younger audiences. Meanwhile, the Trunyan village model presents unique cultural practices, including traditional burial systems, offering insights into local wisdom and traditions. The integration of these models into a WebAR platform allows users to interact with the objects in real-time, including rotating, zooming, and viewing them in augmented environments. This approach enhances cognitive understanding by combining visual, spatial, and textual information.

Fig 3. 3D Model for Kintamani Dog

3.3 Implementation of QR-Code-Based System

The developed system utilizes QR-codes as gateways to digital content. Each QR-code is linked to a specific 3D model and its corresponding narrative. The system was designed to be accessible via standard smartphone cameras and web browsers, eliminating the need for additional applications. Testing results indicate that all participants were able to scan the QR-codes successfully and access the content without significant technical issues. The loading time and system responsiveness were considered acceptable under standard internet conditions. This demonstrates that QR-code technology provides a practical and user-friendly solution for delivering digital educational content in outdoor environments such as geoparks. Furthermore, the use of dynamic QR-codes allows for future content updates without changing the physical codes, supporting system sustainability and scalability.

3.4 User Testing and Evaluation

The evaluation phase involved students, tourists, and local community members who interacted with the system directly. The results show a positive response across several aspects:

1. Usability: Users found the system easy to operate, with intuitive access through QR-code scanning.
2. Visual attractiveness: The 3D models and augmented reality features were considered engaging and visually appealing.
3. Understanding: Participants reported improved comprehension of geological, ecological, and cultural information compared to traditional information boards.
4. Engagement: The interactive features increased user interest and encouraged exploration.

The combination of visual 3D representation and narrative explanation was particularly effective in enhancing learning outcomes. This finding is consistent with previous studies indicating that interactive digital media improves user engagement and knowledge retention.

3.5 Discussion

The results demonstrate that integrating QR-code and WebAR technologies can significantly improve the effectiveness of educational media in geotourism environments. Compared to conventional static information systems, the proposed approach offers several advantages:

1. Interactivity: Users actively engage with content rather than passively reading information.
2. Accessibility: Information can be accessed anytime using personal devices without additional applications.
3. Flexibility: Digital content can be updated and expanded without physical modifications.
4. Sustainability: Reduces the need for printed materials, supporting environmentally friendly practices.

In addition, the involvement of local communities in content development ensures that the information presented is culturally relevant and authentic. This participatory approach strengthens the connection between technology, education, and local knowledge systems. However, several limitations were identified. The system depends on internet connectivity, which may vary across different locations within the geopark. Additionally, further improvements are needed in terms of content diversity, language options, and system optimization for broader user groups. Overall, this study confirms that digital transformation through QR-code and WebAR integration is a promising strategy for enhancing educational tourism in geopark areas. The approach can be replicated in other geotourism destinations to support sustainable education and community engagement.

IV. CONCLUSION

This study presents the development and implementation of an interactive educational information system in Batur UNESCO Global Geopark through the integration of QR-code technology and Web-based Augmented Reality (WebAR). The proposed system effectively addresses the limitations of conventional static information media by providing a more engaging, accessible, and interactive learning experience for visitors. The results indicate that the integration of QR-code as an access point to digital content, combined with 3D visualization and augmented reality, enhances users' understanding of geological, ecological, and cultural aspects of the geopark. The system is easy to use, compatible with common mobile devices, and does not require additional application installation, making it practical for real-world implementation. In addition, the involvement of local communities in content development ensures cultural relevance and supports community engagement in sustainable geotourism.

Despite these positive outcomes, several improvements can be considered for future development. The inclusion of multilingual support and audio narration would increase accessibility for a broader range of users. Expanding the number of QR-code points and enriching digital content coverage across the geopark would provide a more comprehensive learning experience. Furthermore, improving the quality of 3D models and optimizing system performance for low-bandwidth environments are essential for wider usability. Future research may also incorporate quantitative evaluation methods, such as statistical analysis of learning outcomes and user satisfaction, to provide stronger empirical evidence of effectiveness. Additionally, the integration of emerging technologies, including artificial intelligence and adaptive learning systems, offers promising opportunities to further enhance interactive geotourism education.

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