

Development and Evaluation of a QR Code-Based E-Poster for Germplasm Conservation and Environmental Education

Yovita, Mery Berlian

Universitas Terbuka, Indonesia

Email: yovita@ecampus.ut.ac.id

Abstract

This study aimed to develop and evaluate a QR code-based e-poster as a digital medium for germplasm conservation and environmental education. The study employed a research and development approach using the ADDIE framework and was conducted in Pekanbaru in 2021. The participants consisted of 162 Universitas Terbuka students and tutors, including 128 students and 34 tutors. Data were collected through needs analysis, product validation, questionnaires, and staged trials, and analyzed descriptively based on response frequencies. The developed e-poster integrated germplasm information, plant images, morphological descriptions, and environmental education materials on forest and land fires and conservation, complemented by QR code links to additional digital resources. The evaluation results showed consistently high positive responses across all twelve indicators, ranging from 93.2% to 100%. Systematic presentation received the highest positive response (100%), followed by information access (98.1%) and color composition (97.5%). Information delivery and language comprehension each reached 96.3%, while conceptual presentation and text comprehension reached 95.7%. QR code utilization recorded the lowest positive response (93.2%), but remained highly favorable. These findings indicate that the developed e-poster is a practical, readable, and accessible complementary medium for supporting environmental education and germplasm conservation.

Keywords: *germplasm conservation; QR code; e-poster; environmental education; digital learning media*

Abstrak

Penelitian ini bertujuan mengembangkan dan mengevaluasi e-poster berbasis QR Code sebagai media digital untuk mendukung konservasi plasma nutfah dan pendidikan lingkungan. Penelitian menggunakan metode penelitian dan pengembangan dengan kerangka ADDIE dan dilaksanakan di Pekanbaru pada tahun 2021. Subjek penelitian berjumlah 162 responden yang terdiri atas 128 mahasiswa dan 34 tutor Universitas Terbuka. Data dikumpulkan melalui analisis kebutuhan, validasi produk, kuesioner, dan uji coba bertahap, kemudian dianalisis secara deskriptif berdasarkan distribusi respons. E-poster yang dikembangkan memadukan informasi plasma nutfah, gambar dan deskripsi morfologi tumbuhan, serta materi mengenai kebakaran hutan dan lahan dan konservasi yang dilengkapi tautan sumber digital melalui QR Code. Hasil evaluasi menunjukkan bahwa respons positif pada dua belas indikator berada pada rentang 93,2–100%. Sistematika penyajian memperoleh respons tertinggi sebesar 100%, diikuti akses informasi sebesar 98,1% dan komposisi warna sebesar 97,5%. Sementara itu, pemanfaatan QR Code memperoleh respons terendah sebesar 93,2%, tetapi tetap berada pada kategori sangat positif. Temuan ini menunjukkan bahwa e-poster berbasis QR Code yang dikembangkan memiliki potensi sebagai media yang praktis, mudah dibaca, dan mudah diakses untuk mendukung pendidikan lingkungan dan komunikasi konservasi plasma nutfah.

Kata kunci: plasma nutfah; QR Code; e-poster; pendidikan lingkungan; media pembelajaran digital

A. Introduction

Forest and land fires create ecological and educational challenges by increasing emissions, disturbing habitats, and complicating vegetation recovery. Research on fire-related carbon emissions, climate threats to tree distributions, and post-wildfire regeneration shows that plant-community persistence and recovery are central issues in environmental management.¹ Germplasm, the genetic material contained in plant populations and collections, requires systematic documentation because it supports biodiversity conservation, crop improvement, adaptation, and long-term genetic-resource availability. Studies of rice, grapevine, and genebank collections underline the importance of maintaining genetic diversity across ecological and agricultural contexts.²

The challenge is also communicative. Environmental information must be presented in forms that learners and communities can access and interpret. Environmental-literacy research shows that effective education requires reliable content together with communication formats that encourage attention, understanding, and action.^{3,4} Digital media can extend environmental information beyond printed materials and face-to-face explanation, although device availability, connectivity, and information organization remain practical constraints. Evidence from online environmental education suggests that digital delivery is most useful when the medium is clear, structured, and connected to specific learning needs.⁵

An e-poster is particularly suitable for concise visual communication because it can integrate text, images, graphical elements, and links to supplementary materials within a single digital display. This format allows key information to be presented in a structured and visually accessible manner without requiring users to navigate through lengthy documents. In educational contexts, the combination of concise textual explanations and visual representations can help organize complex information into a format that is easier to scan, interpret, and revisit. For environmental education, an e-poster can therefore present essential information such as plant names, morphological characteristics, photographs, conservation messages, and information related to environmental threats in a relatively compact format.

¹Luiz E. O. C. Aragão et al., "21st Century Drought-Related Fires Counteract the Decline of Amazon Deforestation Carbon Emissions," *Nature Communications* 9, no. 1 (2018).

²Saad J. Aljumaili, "Genetic Diversity of Aromatic Rice Germplasm Revealed by SSR Markers," *BioMed Research International* 2018 (2018).

³Katharina Bissinger and Franz X. Bogner, "Environmental Literacy in Practice: Education on Tropical Rainforests and Climate Change," *Environment, Development and Sustainability* 20, no. 5 (2018): 2079-2094.

⁴Tanja Braun, Richard Cottrell, and Paul Dierkes, "Fostering Changes in Attitude, Knowledge and Behavior: Demographic Variation in Environmental Education Effects," *Environmental Education Research* 24, no. 6 (2018): 899-920.

⁵Hans-Erik Edsund and Tobias Broich, "The Impact of Environmental Education on Environmental and Renewable Energy Technology Awareness: Empirical Evidence from Colombia," *International Journal of Science and Mathematics Education* 18, no. 4 (2020): 611-634.

The integration of a QR code further extends the communicative capacity of an e-poster. Because the physical or visual space of a poster is limited, not all supporting information can be displayed directly. A QR code provides an additional access point through which users can connect the main information presented on the poster with more extensive digital resources, including videos, supplementary explanations, assessment materials, reference documents, or other online learning resources. In this way, the QR code functions not merely as a technical feature but as an extension of the information architecture of the e-poster. Users can first obtain the essential information from the poster and subsequently access more detailed materials according to their learning needs.

The combination of e-poster and QR code is particularly relevant to environmental education because environmental topics often involve concepts, visual objects, and supporting information that cannot be fully represented through short textual descriptions alone. Photographs and concise descriptions can introduce users to germplasm and plant characteristics, while linked digital resources can provide additional explanations and multimedia content. This structure allows the e-poster to function as an entry point to broader learning resources while maintaining a concise and visually organized presentation.

Previous discussion of e-poster use also indicates its practicality for organizing and communicating educational information in electronic poster sessions. Accordingly, the e-poster format offers both communicative and organizational advantages: it condenses essential information into a single visual medium while providing opportunities for users to access additional resources digitally. In the present study, these characteristics provide the conceptual basis for developing a QR code-based e-poster that integrates germplasm information with environmental education concerning forest and land fires and conservation.⁶

The study addressed limited access to integrated information on germplasm plants and environmental conditions in fire-prone areas of Pekanbaru. A QR-code-based e-poster was developed using the ADDIE-oriented R&D process, integrating conservation, fire prevention, environmental, and multimedia content. Evaluation focused on users' perceptions of accessibility, presentation, clarity, efficiency, QR-code use, and practicality.

B. Research Method

This research used a research-and-development design in Pekanbaru in 2021. The dataset involved 162 respondents from Universitas Terbuka, consisting of 128 students (79%) and 34 tutors (21%). The product was developed to support tutorial and practical-learning activities as well as broader environmental communication. Development followed the ADDIE logic of

⁶Harriet R. Church and Laura Fazlanie, "Twelve Tips for Organizing a Local or Regional E-Poster Session," *Medical Teacher* (2021): 1-7.

analysis, design, development, implementation, and evaluation. The researchers examined content needs and expected use, designed the visual structure and QR-code links, prepared a prototype, and conducted validation, revision, and user testing.

Data collection used document analysis, validation sheets, questionnaires, and staged trials. Validation reviewed product appropriateness, while questionnaires captured user judgments of usability, presentation, readability, and understanding. Trials progressed from limited testing to field simulation, with formative feedback used for revision. Response data were re-organized descriptively using the frequencies of Strongly Agree, Agree, Less Agree, and Disagree. Positive-response percentages combined Strongly Agree and Agree responses and divided them by 162. The source draft records instrument-validation procedures but does not provide numerical reliability coefficients; therefore, no unreported coefficient is introduced here.

C. Results and Discussion

1. Needs analysis and development experience

The needs analysis was conducted involving 162 respondents to identify the existing conditions, technological readiness, and learning needs relevant to the development of digital learning media. The results indicate that respondents had utilized various digital technologies in learning activities, including Google Classroom, presentation software, smartphones, Zoom, YouTube, Canva, Google Meet, laptops, and reference-management applications. The diversity of platforms used demonstrates that digital technology has become an integral component of the learning environment. However, the availability and use of these technologies did not necessarily correspond to an equivalent level of digital competence. Respondents continued to report difficulties in designing digital learning materials, understanding the characteristics and utilization of virtual learning media, maintaining stable internet connectivity, and accessing adequate technological devices. These findings suggest that the effectiveness of a digital learning product is determined not merely by the quality and relevance of its content, but also by its accessibility, technical feasibility, and compatibility with users' digital competencies.

The findings further demonstrate that the development of digital learning media needs to consider the actual conditions experienced by users during the learning process. Limitations in digital skills may affect users' ability to produce, modify, and utilize learning materials independently, while unstable internet connections and inadequate devices may restrict the accessibility of media that require high bandwidth or advanced hardware. Consequently, digital product development should adopt a user-oriented approach by considering the technological infrastructure, level of digital literacy, and

learning habits of the target users. Such considerations are particularly important in developing visual learning media, because the pedagogical potential of an e-poster can only be realized when users are able to access, understand, and interact with the media effectively. Thus, the needs analysis provides an important empirical basis for ensuring that the resulting product is not only pedagogically relevant but also technically accessible and applicable within the existing learning context.

In addition to identifying technological barriers, the needs analysis revealed the importance of training in the development and utilization of e-posters. Respondents indicated that their ability to develop digital media could be strengthened through structured training, particularly in relation to visual design, digital content organization, and the use of appropriate applications. Previous experience with digital-media production may reduce initial technical barriers; however, it does not necessarily eliminate the need for continuous guidance. This is because the production of effective digital learning materials requires more than operational knowledge of software. Users also need to understand how to select relevant information, organize content systematically, communicate concepts visually, and adapt media to the characteristics of learners and learning objectives. Therefore, training should be positioned as an integral component of digital-media development rather than merely as an additional technical activity.

The importance of continuous support is consistent with research on technology-enhanced learning, which emphasizes that the sustainability and effectiveness of educational technology depend on the integration of technological, pedagogical, and contextual considerations. Technology should therefore function as a means of strengthening learning rather than becoming an end in itself.⁷ Similarly, evidence-based principles in online environmental education emphasize the need to design digital learning environments based on established pedagogical considerations, learner characteristics, and the intended educational outcomes.⁸ In this context, the development of e-posters should be understood as a pedagogical intervention that integrates visual communication, digital accessibility, and learner needs. Accordingly, the needs-analysis findings provide a substantive foundation for developing an e-poster that is not only attractive and informative but also feasible, accessible, and aligned with the technological capacities of its intended users.

⁷ Tobias Ley et al., "Designing Technology-Enhanced Learning Research for Sustainable Impact: The Learning Layers Case," *CEUR Workshop Proceedings* 2676 (2020).

⁸ Eileen G. Merritt et al., "A Systematic Literature Review to Identify Evidence-Based Principles to Improve Online Environmental Education."

2. Product design and QR-code integration

The product presents germplasm information in a visual e-poster that combines the plant name, morphological information, images, explanatory text, prompts, and QR-code links. Core content remains visible at a glance, while linked text and video provide additional detail without overcrowding the poster.

Figure 2. QR-code-based e-poster product design



The QR code functions as an extension layer: users can scan it to reach supporting resources instead of placing all information on the poster. This helps balance concise visual presentation with access to more detailed material.

3. Respondent evaluation of the e-poster

Table 1 consolidates the response distributions that were originally presented across a series of separate graphs. The table shows that positive responses were consistently high. Across the twelve indicators, the combined proportion of Strongly Agree and Agree responses ranged from 93.2% to 100%. This pattern indicates that the product was generally viewed as usable, understandable, and visually organized by the participating students and tutors.

Table 1. Respondent evaluation of the QR-code-based e-poster (n = 162)

Indicator	Strongly agree	Agree	Less agree	Disagree	Positive (%)
Information delivery	55	101	6	0	96.3
Layout	44	110	7	1	95.1
Information access	55	104	2	1	98.1
Effectiveness	33	119	9	1	93.8
Text presentation	50	104	8	0	95.1
QR-code utilization	49	102	11	0	93.2
Color composition	50	108	4	0	97.5
Systematic presentation	41	121	0	0	100.0
Efficiency	50	104	7	1	95.1
Concept presentation	45	110	6	1	95.7
Text comprehension	48	107	6	1	95.7
Language comprehension	48	108	6	0	96.3

Source: Reorganized from the response counts reported in the original study draft.

Systematic presentation received 100% positive responses, followed by information access (98.1%) and color composition (97.5%). These results indicate that organization and visual clarity were major product strengths and helped users relate titles, images, explanations, and linked resources. QR-code utilization produced the lowest positive proportion (93.2%), followed by perceived effectiveness (93.8%). Both remain high, but the less-positive responses point to device readiness, scanning functions, connectivity, and user confidence as practical issues that may limit digital access.

Text presentation (95.1%), conceptual presentation (95.7%), text comprehension (95.7%), and language comprehension (96.3%) were also evaluated favorably. Readability is therefore a core design criterion because environmental literacy requires users to interpret concepts rather than merely notice attractive visuals.^{9,10}

4. Implications for environmental literacy and germplasm conservation

The development of the e-poster has important implications for strengthening environmental literacy because it integrates concise visual information, contextual explanations, and links to extended digital resources within a single learning medium. Environmental literacy is not limited to the acquisition of factual knowledge, but encompasses the interaction of environmental knowledge, values, awareness, and behavioral dimensions that influence how individuals understand and respond to environmental issues. In this regard, a digital medium such as an e-poster cannot independently transform learners' environmental knowledge, values, or behavior. However, it can function as an accessible pedagogical entry point that facilitates exposure to environmental concepts, stimulates attention to specific ecological problems, encourages further exploration through supplementary resources, and provides material for classroom or community discussion.¹¹ The integration of visual and textual information is particularly relevant because environmental issues often involve complex relationships that may be more readily understood when presented through concise, contextualized, and visually organized information. Moreover, the accessibility of digital content enables learners to revisit the material and explore additional sources according to their individual learning needs.

In the context of germplasm conservation, the e-poster provides a means of translating relatively abstract concepts of genetic diversity and plant conservation into

⁹Wei-Ta Fang et al., "Environmental Literacy on Ecotourism: A Study on Student Knowledge, Attitude, and Behavioral Intentions in China and Taiwan," *Sustainability* 10, no. 6 (2018).

¹⁰Daphne Goldman et al., "Influence of 'Green School Certification' on Students' Environmental Literacy and Adoption of Sustainable Practices by Schools," *Journal of Cleaner Production* 183 (2018): 1300-1313.

¹¹ Michaela Maurer and Franz X. Bogner, "Modeling Environmental Literacy with Environmental Knowledge, Values and (Reported) Behavior," *Studies in Educational Evaluation* 65 (2020): 100863.

more concrete and observable learning experiences. The use of plant photographs, morphological descriptions, conservation information, and links to multimedia resources can help learners recognize the characteristics and diversity of plant germplasm while understanding its ecological and environmental significance. Such information can subsequently be connected with broader issues of vegetation recovery, sustainable land management, biodiversity protection, and environmental responsibility, particularly in areas vulnerable to forest and land fires. This integration is important because environmental literacy develops not only through the accumulation of ecological information but also through the formation of awareness regarding the relationship between human activities, ecosystems, and environmental sustainability.¹² Thus, the e-poster can serve as an educational bridge between knowledge of germplasm conservation and broader environmental concerns by presenting conservation practices as part of a larger responsibility for maintaining ecological resilience and biodiversity.

D. Conclusion

This study developed a QR-code-based e-poster for germplasm and environmental information in fire-prone contexts through needs analysis, design, validation, revision, staged trials, and user evaluation. Among 162 respondents, positive evaluations were consistently high across twelve indicators; systematic presentation was strongest, while QR-code utilization was lowest but still highly positive. The e-poster can therefore complement distance-learning materials and environmental communication by combining concise visual content with QR-based access to additional information. Further studies should directly measure learning and conservation outcomes, involve more diverse participants, and report complete psychometric evidence.

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¹² Sheryn D. Pitman, Christopher B. Daniels, and Paul C. Sutton, “Ecological Literacy and Socio-Demographics: Who Are the Most Eco-Literate in Our Community, and Why?” *International Journal of Sustainable Development and World Ecology* 25, no. 1 (2018): 9–22.

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