

Designing Immersive Environmental Education Media Based on Gamification and Community Involvement for Early Childhood

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Abstract. Environmental education for young children needs to connect environmental concepts with concrete experiences that are close to their everyday lives. This study aims to formulate a framework for designing environmental education media for early childhood by integrating community environmental practices, visual translation, and interactive activities, while identifying further development toward gamification and immersive learning. A qualitative design-based approach was employed through field observations, discussions with residents, and needs identification at Kampung Proklam, Jawa Barat, where waste management and hydroponic cultivation are part of community environmental practices. The findings reveal a gap between existing environmental practices and learning media that are accessible to young children. These findings informed the development of visual-interactive media using mascot characters, simplified illustrations, colour differentiation, worksheets, stickers, and activities such as colouring, matching, sorting, connecting, and object placement. The prototype demonstrates initial gamification elements through task-oriented and playful interaction; however, a more complete gamification structure involving storytelling, mission, challenge, progress, and reward remains a direction for further development. Similarly, immersive learning is positioned as a future design direction by connecting visual media with physical interaction, real objects, environmental exploration, and community facilities rather than relying on advanced immersive technologies. Based on these findings, a five-stage framework was formulated: (1) identifying environmental contexts, (2) translating environmental knowledge into child-appropriate visual representations, (3) developing interactive and playful activities, (4) integrating community contexts, and (5) directing further development toward gamified and immersive learning experiences. The framework offers a contextual and adaptable basis for developing environmental education media in communities with limited technological resources.

Keywords: *early childhood, environmental education, immersive, visual, design*

INTRODUCTION

Children begin to understand the environment through everyday experiences such as disposing of waste, watering plants, and observing conditions around their homes. Environmental education in early childhood therefore needs to be delivered through direct experiences and contexts that are familiar to children, allowing environmental concepts to be understood in more concrete ways. Education for sustainability in early childhood increasingly emphasizes children's active involvement in environmental experiences [1], while research highlight the importance of learning approaches that respond to children's developmental characteristics and everyday contexts [2]. The challenge, therefore, is not only determining what children need to know about the environment, but also translating that knowledge into meaningful learning experiences.

Environmental concepts such as waste sorting and hydroponic systems may be difficult for young children to understand when presented only through verbal explanations. Learning activities should provide opportunities for children to observe, explore, classify, and interact with objects or their visual representations. Hands-on approaches can support children's understanding and engagement in environmental learning [3]. In the Indonesian context, also identified a need for visual and interactive media that correspond to the characteristics of early childhood learners [4]. These findings suggest that environmental education media should not merely convey information, but should also transform relatively abstract concepts into activities that children can observe and perform directly.

A variety of creative media have been used in environmental education for young children; however, their development is not always connected to the contexts in which children learn. Research shows that arts-based approaches are still often positioned primarily as tools for expression or learning support, while the relationship between visual forms, sustainability content, and knowledge construction has not yet been fully integrated [5]. Community participation in early childhood education for sustainability also remains fragmented [6]. A similar situation was identified in Kampung Proklam, Jawa Barat, Indonesia, where community-based waste management and hydroponic cultivation are already practiced, yet environmental education for young children remains limited by the lack of media suited to their learning characteristics and needs. This reveals a gap between environmental practices embedded in the community and the ways such knowledge is translated into accessible learning experiences.

This gap positions visual communication design not only as a means of simplifying information, but also as a basis for developing children's interaction with environmental content. Such interaction can be extended through gamification, which applies game elements in non-game contexts [7]. Gamification may involve storytelling, missions, challenges, progress, and rewards that provide structure and purpose to children's activities. Further development may also be directed toward immersive learning. Immersion does not necessarily depend on VR or AR, but can emerge through the integration of visual elements, physical activity, exploration, and real-world environments [8]. In this study, however, full gamification and immersive learning are positioned as directions for further development rather than tested outcomes.

Previous studies have emphasized the value of place-based education in connecting sustainability learning with local environments and community life [9], while other research indicates that gamified and immersive approaches still require stronger contextual integration and evaluation [10] [11]. Research remains limited in explaining how existing community environmental practices can be translated into visual language and interactive activities for young children, and subsequently developed toward gamified and immersive learning experiences.

Accordingly, this study aims to formulate a design framework for early childhood environmental education media through the identification of environmental contexts, visual translation, interactive activities, and integration of community practices. The framework also identifies directions for developing gamification and immersive learning through physical interaction, exploration, and engagement with real-world environments.

METHODS

Study area

This study employed a qualitative approach grounded in the design process to identify needs and formulate a framework for early childhood environmental education media. This approach is consistent with educational design research, which connects problem exploration with the development of design solutions [12]. The study was conducted in Kampung Proklam, with community residents serving as sources of information regarding waste management practices, hydroponic cultivation, and environmental education needs. Young children were positioned as the target users of the media; however, the effectiveness of the media was not directly tested at this stage.

Data were collected through field observations, discussions with residents, and identification of media needs. The data were analyzed qualitatively by examining relationships among the environmental context, user needs, visual design decisions, and forms of media interaction, following the principles of thematic analysis [13]. The findings were then formulated into a design framework, while full gamification and immersive learning experiences were positioned as directions for further development that require subsequent validation.

RESULTS AND DISCUSSION

Result-1 Environmental Context and Media Needs

Field observations in Kampung Proklam identified two environmental practices that became the main sources of learning content: waste management and hydroponic cultivation. Both practices were already part of community activities, but learning media specifically designed to introduce them to young children remained limited. Discussions with residents indicated the need for media that could translate these practices into forms that were more accessible to early childhood learners.

Based on these findings, the learning content was focused on waste categorization and basic hydroponic concepts. The waste topic introduced organic, inorganic, and hazardous waste, while the hydroponics topic introduced plants and basic cultivation components. The main design challenge was therefore not the

absence of environmental knowledge within the community, but how this knowledge could be transformed into child-appropriate learning experiences.

Result-2 Visual and Interactive Media Development

The design process translated these environmental practices into visual and interactive media. Waste management concepts were represented through simplified mascot characters, while hydroponic practices were translated into illustrations of plants and basic equipment. Visual forms were simplified to improve recognition and support differentiation among environmental categories.

The visual elements were then developed into activity-based media through colouring, sticker placement, matching, connecting, and classification tasks. These activities allowed children to interact with environmental information rather than merely observe it. The prototype therefore demonstrated two related functions of visual communication design: translating environmental knowledge into recognizable visual forms and transforming those forms into interactive learning activities.

Result-3 Formulation of the Design Framework

Based on these findings, a five-stage framework was formulated: (1) identifying environmental contexts, (2) translating environmental knowledge into child-appropriate visual representations, (3) developing interactive and playful activities, (4) integrating community contexts, and (5) directing further development toward gamified and immersive learning experiences.

The current prototype contains initial game-like interactions, including task completion, matching, classification, and simple physical engagement with visual elements. However, these features do not yet constitute a complete gamification system, nor do they provide sufficient evidence of an immersive learning experience. Gamification and immersion are therefore positioned as directions for further design development rather than validated outcomes.

The framework can be summarized as:

Environmental context → visual translation → interactive and playful activities → community integration → gamified and immersive development

Discussion

The findings suggest that environmental education media for young children can be developed from environmental practices that already exist within the community. This supports previous studies showing that sustainability learning becomes more meaningful when it is connected to children's everyday environments and local practices [14] [15]. In this study, Kampung Proklim functions not only as the research site but also as a source of environmental knowledge that informs both the content and direction of the media design.

A second contribution concerns the role of visual communication design. The findings indicate that visual design does more than make environmental information attractive. It functions as a mechanism for knowledge translation, transforming concepts such as waste categories and hydroponic systems into characters, illustrations, and interactive actions that are easier for young children to recognize and use. This interpretation is consistent with [16], who emphasize perceptual appropriateness in instructional illustrations, and [17], who highlight the importance of interactive visual media in early childhood learning.

The prototype also provides an initial foundation for further development toward gamification. At the current stage, the activities primarily involve simple game-like interactions rather than a complete gamification structure. According to [7], gamification involves the deliberate application of game-design elements in non-game contexts. Accordingly, elements such as storytelling, missions, challenges, progress, and rewards are positioned as part of the next design iteration rather than as features already tested in the current prototype.

Similarly, immersive learning is treated as a direction for future development rather than an achieved outcome. In this study, immersion is not limited to the use of VR or AR, but may be developed by connecting visual media with physical interaction, real objects, and the actual environment of Kampung Proklim. This position is consistent with [8], who describe immersive learning as an active experience that can take place in both physical and digital environments.

Overall, the study proposes a design approach that moves from local environmental practices to visual translation and interactive learning, while reserving more advanced gamification and immersive experiences for further development and validation. This approach is particularly relevant for communities with limited technological resources because it does not require advanced technology as the starting point for environmental learning.

CONCLUSION

This study formulated a design framework for early childhood environmental education media by connecting environmental contexts, visual translation, interactive activities, and community practices. The findings show that waste management and hydroponic practices in Kampung Proklam can be translated into child-appropriate visual and interactive learning media. The resulting five-stage framework covers environmental context identification, visual translation, interactive and playful activities, community integration, and further development toward gamified and immersive learning experiences.

Theoretically, the study positions visual communication design as a mechanism for knowledge translation between community environmental practices and children's learning experiences. Practically, the framework offers a contextual and low-technology approach that may support designers, educators, and community-based environmental programs in developing learning media from locally available practices and resources.

The study is limited to needs identification, design development, and an initial prototype; therefore, the effectiveness of the media, full gamification, and immersive learning have not yet been empirically tested. Future studies should evaluate children's engagement, environmental understanding, motivation, and presence/immersion, while also testing the framework across different communities and environmental themes.

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