Promoting Environmental Knowledge Towards Community Independence in Waste Management: Developing A Gamification Module Based on Nggusu Waru Local Wisdom

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Article Info	Abstract
	Environmental knowledge is a fundamental foundation for shaping community independence in waste management. This study aims to develop a gamification-based module integrating the eight pillars of Nggusu Waru local wisdom to enhance students' environmental knowledge as a basis for achieving community self-reliance in waste management. This Research and Development (R&D) employed the Dick and Carey model, involving seventh-semester students at Universitas Nggusu Waru Bima. Data were collected through expert validation sheets, student response questionnaires, environmental knowledge tests (pretest-posttest), observation, and interviews. The results showed that the module was highly valid (material expert: 4.63, media expert: 4.53) and practical (4.58). The module's effectiveness was demonstrated by a significant increase in environmental knowledge scores with an N-Gain of 0.63 (medium category) and high student engagement (87%). The integration of Nggusu Waru values successfully connected environmental knowledge with local cultural wisdom, creating a strong foundation for developing community independence in waste management. This study concludes that the gamification module based on Nggusu Waru local wisdom is valid, practical, and effective in enhancing environmental knowledge as a step toward community self-reliance in waste management.

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1. INTRODUCTION

Waste management in Indonesia remains a serious challenge that requires comprehensive action. According to data from the Ministry of Environment and Forestry (Kusdiah et al., 2024), Indonesia generates 68 million tons of waste annually, with management still suboptimal. Lack of public knowledge about proper waste management is a contributing factor to its low effectiveness (Nanda et al., 2024).

Higher education plays a strategic role in equipping students as future leaders with adequate environmental knowledge, particularly in waste management. The Environmental Knowledge course at Nggusu Waru Bima University is designed to provide students with a conceptual and practical understanding of environmental management, with a particular focus on waste management towards community independence.

A preliminary survey of 30 seventh-semester students showed that 68% of respondents considered the waste management material in lectures to be theoretical and poorly connected to the local context. Furthermore, only 40% of students understood the local wisdom of "Nggusu Waru," which actually contains relevant values for sustainable waste

management. These findings indicate the need for innovative and contextual learning approaches.

Nggusu Waru as the leadership philosophy of the Bima community contains eight pillars of values that are relevant to independent waste management, namely: (1)*Macia is the spirit of piety*(piety) as the basis of environmental ethics, (2)*I don't know the science, come on, brother*(science and wisdom) in waste management decision making, (3)*I have some*(courage) to enforce waste management regulations, (4)*These texts are pages*(patience) in facing the challenges of waste management, (5)*I'm not going to earn money*(consistency) between knowledge and practice, (6) Mataho hidi ro tohona (exemplary behavior) in waste management, (7)*London came and went*(maintaining ancestral heritage) in environmental preservation, and (8)*Bright sun*(providing benefits) through productive waste management (Ruslan et al., 2023).

Gamification as a learning approach has proven to be effective in increasing motivation and conceptual understanding (Wangi, Wangi, et al., 2018), (Dwyer, 2018). However, previous research is still limited to increasing general knowledge without focusing on waste management and community self-sufficiency (Aufa et al., 2025). This research offers innovation through the integration of gamification with the local wisdom of Nggusu Waru specifically to improve environmental knowledge oriented towards community self-sufficiency in waste management. The application of gamification in the world of education has proven to be able to increase motivation (Wangi, Setyosari, et al., 2018), student involvement(Dwyer, 2018), and effective for improving critical thinking(Abbassyakhrin et al., 2024).

Based on this background, this study aims to: (1) Develop a gamification module based on Nggusu Waru local wisdom to increase environmental knowledge about waste management, (2) Test the validity and practicality of the module, (3) Analyze the effectiveness of the module in increasing environmental knowledge as a basis for community independence in waste management.

2. RESEARCH METHODS

This study used the Research and Development (R&D) method with the Dick and Carey model (Dick et al., 2015). The study was conducted for 12 months at Nggusu Waru Bima University.

2.1. Research Subjects

The research subjects consist of:
1. Subject matter experts (environmental and cultural) and media experts for validation
2. 30 seventh semester students of the Biology Education Study Program for the trial

2.2. Research Instruments

Research instruments include:
1. Expert validation sheet (Likert scale 1-5)
2. Environmental knowledge test (pretest-posttest) focuses on waste management
3. Student practicality and engagement questionnaire
4. Participation observation sheet
5. In-depth interview guidelines

2.3. Development Procedures

The procedure follows the Dick and Carey model (Dick et al., 2015) with an emphasis on:
1. Identification of objectives: Increasing knowledge of waste management for community independence

2. Instructional analysis: Integrated waste management competency of Nggusu Waru values
3. Development of a module with 8 levels according to the Nggusu Waru pillars.

2.4. Data analysis

The data were analyzed descriptively quantitatively using the N-Gain test to measure the increase in knowledge.

3. RESEARCH RESULTS AND DISCUSSION

3.1.Research result

3.1.1. Module Development with a focus on integrated waste management knowledge of the eight pillars of Nggusu Waru:

Level 1-2: Basic knowledge of integrated waste management Level 3-4: Integrated waste sorting and processing techniques Level 5-6: Integrated independent waste management system Level 7-8: Level 7-8 London's integrated community self-reliance strategy

3.1.2. Validation and practicality of the Module

The results of the validation and practicality test of the module show:

Table 1. Module Validation Results

Assessment Aspects	Subject Matter Expert Score	Media Member Score	Category
Suitability of waste management materials	4.6	-	Very Valid
Integration of Nggusu Waru values	4.8	-	Very Valid
Quality of learning media	-	4.5	Very Valid
Rate-rate	**4.63**	**4.53**	**Very Valid**

Table 2. Practicality Test Results

Assessment Aspects	Average Score	Category
Ease of use	4.6	Very Practical
Relevance to waste management	4.7	Very Practical
Rate-rate	**4.58**	**Very Practical**

The module's high level of validity and practicality demonstrates that the integration of gamification and Nggusu Waru local wisdom can be developed into a feasible learning medium. This success aligns with research by Semaranata et al. (2024), which found that integrating local wisdom into learning can increase the relevance and contextuality of the material.

The high expert validation score for the integration of Nggusu Waru values (4.8) indicates a strong foundation for the cultural approach to environmental education. Values such as Kate (truth/honesty) and Sori (responsibility) in the Nggusu Waru philosophy are highly relevant to the principles of sustainability and environmental ethics. This confirms the findings of Ruslan et al., (2023) regarding the potential of Nggusu Waru values in strengthening character.

From a media perspective, an interactive and user-friendly interface is a determining factor in the module's practicality. Gamification features such as the badge system and leaderboard successfully create an effective reward

mechanism to maintain student learning motivation. This finding is consistent with research by Wangi et al. (2018), which states that gamification can create a fun and challenging learning environment.

3.1.3. Module Effectiveness

Results of the module effectiveness test in increasing environmental knowledge:

Table 3. Environmental Knowledge Enhancement

Variables	Pretest	Posttest	N-Gain	Category
Waste Management Knowledge	58.3	82.7	0.63	Currently

The increase in environmental literacy with an N-Gain of 0.63 indicates that the developed interactive module was effective in achieving learning objectives. This effectiveness was evident not only in the increase in cognitive scores but also in the changes in student attitudes and behavior observed during the learning process.

The high level of student engagement (87%) was a key factor in the module's success. This demonstrates that the gamification approach combined with contextual, local content can create an immersive learning experience. This finding aligns with research by Dwyer (2018), which shows that gameful engagement can increase student active participation and critical thinking.

The integration of Nggusu Waru values into gamification activities successfully bridges the gap between theoretical knowledge and practical application. For example, in a campus waste management simulation, students not only apply technical knowledge about waste management but also internalize the value of Sanggupu (togetherness) through team collaboration. This approach aligns with the contextual learning concept emphasized by Idris (2023) in optimizing character education through local wisdom.

3.2.Discussion

Explaining research data
3.2.1. Integration of waste management knowledge with local wisdom

The increase in environmental knowledge with an N-Gain of 0.63 demonstrates the module's effectiveness in equipping students with a comprehensive understanding of waste management. The integration of Nggusu Waru values successfully contextualized knowledge relevant to local culture (I.N. Semaranata et al., 2024) (Idris, 2023).

The value of Mataho mori ra (giving benefits) serves as the philosophical foundation for developing knowledge about the circular waste economy. Students not only understand waste management techniques but also the economic value of proper waste management (Gustina, 2021). This aligns with the concept of community independence, which views waste as a potential resource.

3.2.2. Environmental Knowledge as the Foundation of Community Independence.

The high level of student engagement (87%) in learning indicates that the gamification approach combined with local wisdom is effective in building interest and in-depth understanding of waste management (Wangi et al., 2018) (Dwyer, 2018). The knowledge gained by students is an important foundation for developing community independence in waste management.

The value of Ma dinga nggahi labo rawi (consistency in words and actions), integrated into the module, helps students understand the importance of aligning theoretical knowledge with practical waste management (Ruslan et al., 2023). This understanding is essential for developing agents of change who can foster community independence.

3.2.3. Strategy Towards Community Independence.

This module focuses not only on knowledge transfer but also on developing students' abilities as potential drivers of community independence. Through simulations and projects based on the value of Mataho hidi ro tohona (exemplary behavior), students are trained to be role models in good waste management.

Knowledge of an integrated waste management system with the value of Londo ro mai dou ma taho (protecting ancestral heritage) creates awareness that good environmental management is part of preserving cultural heritage (Idris, 2023). This approach builds a sense of ownership and collective responsibility, which are fundamental principles of community independence.

4. CONCLUSION

Based on the research results, it can be concluded:
1. A gamification module based on Nggusu Waru was successfully developed with a focus on waste management knowledge for community independence.
2. The module is proven to be valid and practical with an average score of >4.5
3. The module effectively increases environmental knowledge (N-Gain 0.63) as a basis for community independence in waste management.

5. ACKNOWLEDGEMENT

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