



Design Game Uwuhpoly for Improving Waste Literacy in Elementary School Children in Surabaya

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ABSTRACT

The low level of waste literacy among elementary school students, along with the limited availability of engaging, contextually relevant learning media, has become a major challenge in fostering early environmental awareness. This Study aimed to develop and evaluate the effectiveness of Uwuhpoly, an educational board game designed to improve waste literacy among elementary school students in Surabaya. The method R&D approach using the ADDIE model, which consists of the stages of analysis, design, development, Implementation, and evaluation. The research subjects were 142 students from Grades II to VI at an elementary school in Surabaya, selected through purposive sampling. Data were collected using waste literacy questionnaires (pretest-posttest), observation sheets, and teacher responses. Data analysis used descriptive statistical techniques and N-gain to assess improvements in students' waste literacy. The results of expert validation showed that Uwuhpoly received an average score of 4.51, indicating that the game is feasible for classroom implementation. The implementation results demonstrated a significant improvement in students' waste literacy, with pretest-posttest score increases ranging from 35.7% to 46.7%, and an overall literacy improvement of approximately 85%. Therefore, Uwuhpoly has strong potential to be integrated into science learning (IPA), civic education (PPKn), and the Pancasila Student Profile reinforcement program as an alternative environmental literacy-based learning medium in elementary schools.

Keywords

Educational Game
Elementary School
Environmental Education
Uwuhpoly
Waste Literacy

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**Introduction**

Waste management remains a major environmental challenge in urban areas, including Surabaya, Indonesia, where rapid population growth and urbanization have significantly increased municipal solid waste volumes. Uncontrolled waste production, limited waste management facilities, and low public awareness of proper waste handling have contributed to serious environmental pollution. According to the city produces approximately 1,600 tons of waste per day, of which around 60% consists of organic waste, mainly food and vegetable residues. Meanwhile, plastic waste accounts for about 14% of total waste, equivalent to approximately 111,000 tons per year . To reduce plastic waste, the Surabaya City Government issued Mayor Regulation No. 16 of 2022 concerning the Reduction of Plastic Bag Usage, which has successfully reduced plastic waste by approximately 0.6 tons per day in modern markets and supermarkets [1]-[3]. In addition, the city has developed several waste management facilities, such as the Recycling Center in Jambangan, which processes around 6–7 tons of waste per day. This facility processes organic waste into compost and recycles inorganic waste, reducing the volume of waste sent to landfills. Despite these initiatives, several challenges remain, particularly in increasing community participation in waste sorting practices and reducing the excessive use of single-use plastics. Therefore, strengthening environmental awareness and responsible waste management behavior remains a priority for sustainable urban development[4]- [7].

One long-term strategy to address waste management problems is through waste literacy education, which aims to develop knowledge, attitudes, and responsible behaviors toward environmental sustainability. Waste literacy refers to an individual's ability to understand waste-related issues, make informed decisions about waste management, and adopt environmentally responsible practices in daily life. Elementary school students represent a particularly important target group for environmental education because childhood is a critical period in which values, attitudes, and habits can be formed and sustained into adulthood [8]-[10]. Early environmental education can therefore contribute significantly to the development of long-term pro-environmental behavior [11]-[14]. However, teaching waste literacy to young learners is not always effective when traditional teaching methods are used. Conventional approaches often rely heavily on teacher-centered instruction, which may appear monotonous and less engaging for children [11], [15]-[17]. As a result, students may

have limited motivation to engage actively with environmental learning topics. To address this challenge, game-based learning has been widely recognized as an effective instructional approach that promotes student engagement, motivation, and active learning. Through educational games, students can learn while playing, experiencing interactive learning that facilitates deeper understanding and retention of knowledge [18],[19]

Although environmental education and waste literacy have received increasing attention in recent years, many elementary schools still lack innovative, engaging learning materials specifically designed to teach waste management concepts [11],[20]-[23]. Environmental education in schools is often limited to theoretical explanations, without providing interactive learning experiences that actively encourage students to apply waste management practices in real-life contexts [24],[25]. Furthermore, existing educational tools rarely integrate game-based learning strategies with environmental issues, particularly in urban waste management. As a result, there remains a need for innovative educational media that can simultaneously improve students' knowledge, attitudes, and behavioral awareness regarding waste management [26].

To address this gap, this Study develops an educational game called "Uwuhpoly." The game adapts the concept of the popular board game Monopoly while integrating themes of waste management and environmental responsibility. Through gameplay, students are introduced to different types of waste, waste sorting practices, and the environmental impacts of improper waste disposal. At Uwuhpoly, students take on the role of waste managers who must make decisions about the waste management situations presented in the game. These decisions allow students to understand the consequences of environmental behavior while simultaneously developing their environmental awareness. Therefore, the objective of this Study is to develop and evaluate the effectiveness of the Uwuhpoly educational game in improving waste literacy among elementary school students. It is expected that this game-based learning approach can enhance students' understanding of waste management, encourage environmentally responsible behavior, and provide an innovative alternative for environmental education in elementary schools.

Material and Methods

This Study employed a Research and Development (R&D) approach using the ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation (see Figure 1). The ADDIE model was selected because it provides a systematic framework for designing, developing, testing, and evaluating educational media to ensure its effectiveness and usability in learning contexts [27]. Through this model, the development process for the Uwuhpoly educational game was carried out iteratively to ensure the product was pedagogically appropriate and effective in improving students' waste literacy.

The Study was conducted at SDN Menanggal 601 Surabaya, involving elementary school students from Grades II to VI. The research subjects were selected using a purposive sampling technique, a nonprobability sampling method in which participants are selected based on specific criteria relevant to the research objectives [28]. The criteria used in this Study were:

1. Students who had previously received basic environmental education related to waste management.
2. Students who understood the game instructions and participated in collaborative activities.
3. Students who were present during the Implementation of the learning activity using the Uwuhpoly game.
4. Classes whose teachers agreed to participate in the research implementation.

Based on these criteria, 142 students from five classes were selected as the research sample to obtain representative data on the effectiveness of the Uwuhpoly game in improving waste literacy.

A. Research Instruments

1. Waste Literacy Questionnaire

The waste literacy questionnaire was designed to measure students' understanding of waste management before and after playing the Uwuhpoly game. The questionnaire items were developed based on environmental literacy frameworks [29] and waste management education concepts. The indicators measured include:

- Knowledge of waste types (organic, inorganic, and hazardous waste).
- Understanding of waste sorting practices.
- Awareness of environmental impacts caused by improper waste disposal.
- Knowledge of the 3R principles (Reduce, Reuse, Recycle).
- Responsibility and awareness toward maintaining environmental cleanliness.

Responses were measured using a Likert scale, allowing quantitative assessment of students' literacy levels.

2. Observation Sheet

Observation sheets were used to record students' attitudes and behavioral changes during the gameplay. The aspects observed included:

- Student engagement during the game
- Participation in group discussions
- Ability to apply waste sorting concepts in the game
- Demonstration of environmentally responsible behavior

3. Teacher Review Form

A teacher review instrument was used to evaluate the effectiveness and practicality of the Uwuhpoly game. Teachers assessed:

- The suitability of the game for learning objectives
- Student engagement and motivation
- Ease of use of the game in classroom learning
- The potential of the game to improve environmental awareness

B. Instrument Validity and Reliability

1. Content Validity

Content validity was evaluated by three experts in science education and environmental education. The experts assessed the relevance, clarity, and appropriateness of each item using a validation rubric. The Content Validity Index (CVI) was calculated to determine the degree of agreement among experts [30].

2. Construct Validity

Construct validity of the questionnaire was assessed using [Pearson product-moment correlations](#) between items and total scores. Items with correlation coefficients greater than the critical value (r -table) were considered valid [31].

3. Reliability

Instrument reliability was assessed using [Cronbach's alpha](#) to measure internal consistency. An instrument is considered reliable if the Cronbach's Alpha value is greater than 0.70

4. Data Analysis

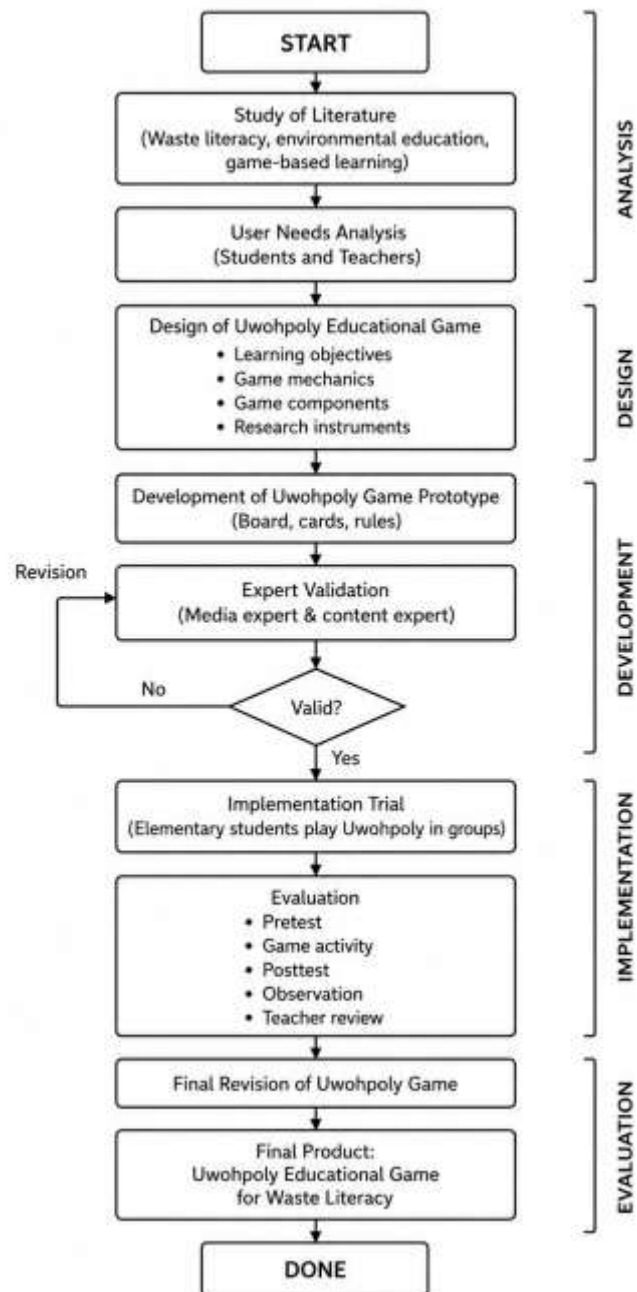
The collected data were analyzed using both [descriptive and inferential statistical techniques](#) to provide a more robust evaluation of the Uwuhpoly game's effectiveness. Descriptive statistics were used to describe the distribution of students' waste literacy scores, including the [mean, percentage, and standard deviation](#). In addition, qualitative data obtained from observations were analyzed using thematic analysis to identify patterns in students' engagement and behavioral changes during the game. To measure improvement in students' waste literacy, the [Normalized Gain \(N-Gain\)](#) score was calculated from pretest and posttest scores. The N-Gain formula is expressed as follows [32].

$$N-Gain = \frac{Posttest\ Score - Pretest\ Score}{Maximum\ Score - Pretest\ Score} \quad (1)$$

The interpretation of N-Gain values follows these criteria (Table 1).

Table 1. N-Gain Criteria

N-Gain Score	Category
$g \geq 0.70$	High
$0.30 \leq g < 0.70$	Medium
$g < 0.30$	Low

**Fig. 1.** Method study development R&D with the ADDIE

Results

A. Analysis

From the Interview with the teacher, showing that although the educational environment has taught, topic literacy is rubbish. Not yet. Lots were discussed profoundly and practically.

The teacher feels the need to use a more engaging method to increase students' understanding of management Waste. While that, surveys show that students have limited knowledge of types of Waste and often do not understand the sorting method for Waste. This shows the need for increased literacy through more effective and attractive methods, such as educational games. Analysis of the curriculum reveals that the material literacy environment includes several lessons that specifically discuss topics relevant to a comprehensive [8], [11], [14], [33], [34], [35], [36]. The curriculum focuses on general environmental concepts but does not sufficiently emphasize practical aspects, such as sorting Waste and recycling. Therefore, Uwuhpoly developed a comprehensive curriculum, with a current draft that includes a more structured, applicable, and appropriate literacy component, aligned with the basic standard of learning. At observation, children's styles and interests in games are studied and assessed [37], [38]. Observation conducted in the school environment to understand how children respond to interactive learning methods, especially in the form of a game. Information is used to ensure that the game Uwuhpoly is in accordance with the characteristics of children and is good from the aspects of content, design, and method of play. Observation results show that children have a strong interest in learning activities that involve interactive and visual elements. Children are more enthusiastic when studying through fun, colorful media than through lecture or text. They also show a positive response to challenging games. To make a decision or solve a problem, which is a main focus at Uwuhpoly.

B. Design

Designing draft game Uwuhpoly, including rules of the game, board games, cards containing information about types of garbage, and instructions for games [37], [38], [39]. The board game Uwuhpoly is designed with an attractive, informative layout to support objective education-related management tasks. On the board, various boxes represent important actions and locations, such as the "Bank Sampah" box, which symbolizes the organized collection and processing of rubbish, and the "Garbage Facts" box, which provides educational information to players. Some other boxes, like "Garbage Quiz ", "Guess Waste ", and "Your Assignment" encourage player interaction. By answering questions or completing tasks, they are certain to increase their knowledge of types of waste and their management. The "Prison" box functions as punishment for the player who violated the rule related to Waste, while the boxes "Truck "Garbage ", and "TPS" add realism to the collection and disposal process of Waste. boxes This is filled with interesting illustrations, attention, and destination. To make it easier to understand the importance of managing the game. Design a game, uwuhpoly, based on the picture shown in Fig. 2.

Develop an instrument to measure the effectiveness of the game in improving literacy. Waste. Instrument: This is in the form of sheet observations and questionnaires that measure

the child's understanding before and after play at Uwuhpoly. Instructions for the game: the player throws the dice and advances according to the number of steps shown. When landing in the Waste zone, the player takes cards and reads rubbish information, then decides on the action to take. The player can buy a recycling zone repeat to get point additions and develop environmental management strategies [38], [40].

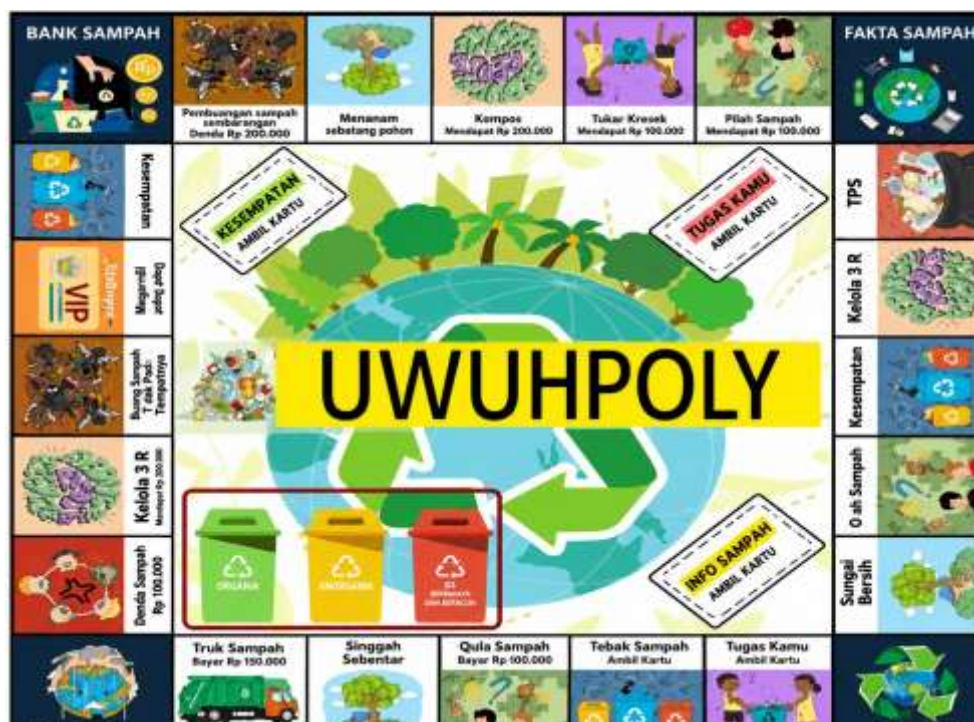


Fig. 2. Designing game Uwuhpoly

Games in progress until all action on the board is finished, or the game time finishes. To measure the effectiveness of the game, an increase in Waste Literacy, an instrument was developed in the form of a sheet of observations and a questionnaire. An observation sheet designed to measure players' active participation, understanding, and errors during games. Observed indicators covering how many active players follow the game, accuracy in sorting waste, and the strategies used, such as utilization of recycling zones, repetition, and card education. The questionnaire consists of 10-15 questions, both closed- and open-ended, to measure improvement in understanding before and after play. Example question includes, "What is the difference between rubbish organic and inorganic ?" "Why?" important sorting rubbish in accordance, "What kind ?" and "Mention it?" example action recycle correct repeat. Instructions: Use an instrument that involves an observer during the game, as well as a questionnaire for children administered before and after playing Uwuhpoly. Observed results and answered the questionnaire, then compared to evaluate the effectiveness of increasing literacy and awareness in the environment. With the instrumentation, the evaluation is expected to show how far the game helps children with waste management and forms environmental habits that lead to better developmental outcomes. Instrument Measurement.

In general, results from the observation and questionnaire indicate that the game Uwuhpoly is effective in increasing Waste Literacy and teaching management strategies to children. Games This succeeds in motivating players to be more aware of the importance of sorting Waste and to engage in more responsible behavior.

Table 2. Development Results Instrument Measurement

Aspect	Observation result
Participation active player	The majority of players are actively involved during games.
Accurate sorting of rubbish	Players show improved accuracy in sorting the correct trash during games
Utilization of recycling zones repeats.	Player, in a way, is consistent with using recycling zones, repeat, and card education to add points.
Understanding beginning	Most children have only a basic knowledge of waste and recycling.
Understanding after play	Children can answer questions with more accurate and capable mentions, for example, action, recycle, and exact repeat.
Improvement literacy	85% of participants who initially answered "No" can explain the importance of sorting rubbish correctly after the game.

C. Development

Test the validity of a design game with an invited expert in an educational environment for the development of learning media. For providing input on the game design. Revision done based on expert input for the repair quality game. All data has been collected and analyzed sustainably, using quantitative, qualitative, and aggregated data, and the results have been analyzed. This is used to understand and address research problems. Games uwuhpoly, which has been designed and developed, has undergone validation by 2 validators or experts in IPBA education and science, with 3 tests, and has been analyzed descriptively. Figure 3 shows the results of the validator. Figure 3 shows the results of the validator.

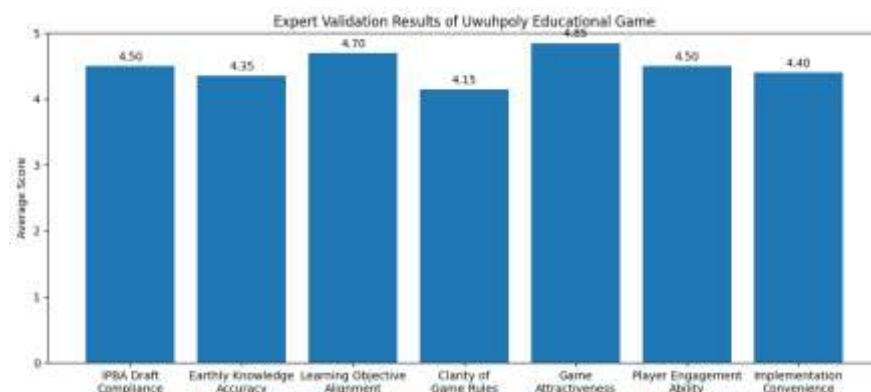


Fig. 3. Validation Results

The game underwent 3 tests to ensure quality design. Revision done after each test based on validator input. The validation score from the experts was used to determine the level of validity of the game. Notes and suggestions from the validator are used for repair design. Based on the average score validation (4.51), game Uwuhpoly is considered valid with a few minor revisions. Game This Ready tested, try more, carry on for Implementation in learning.

D. Implementation

Implementing the game Uwuhpoly in some classes at a school-based in Surabaya with teacher guidance. Every session, a game runs for 1 hour with a group of different students. Using sheet observations and a questionnaire to collect data on students' understanding of change and attitudes toward literacy rubbish before and after playing at Uwuhpoly—qualitative and quantitative data were collected during the session. The implementation results are presented in Fig. 4 and Fig. 5.

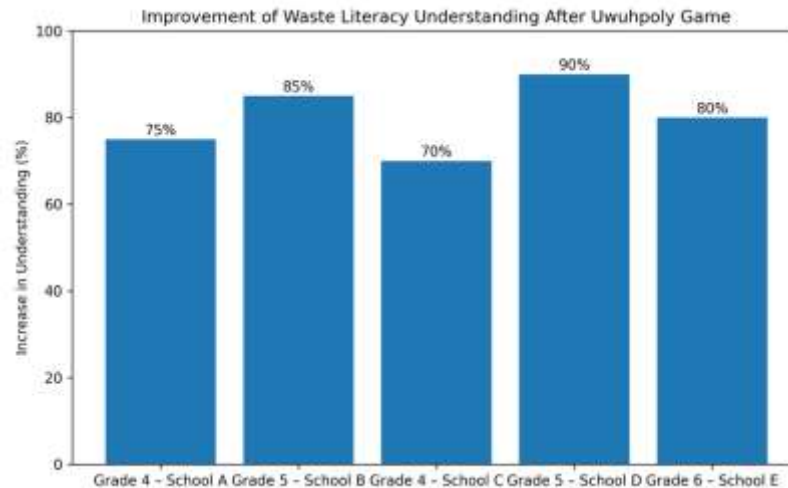


Fig. 4. Observation Results Implementation

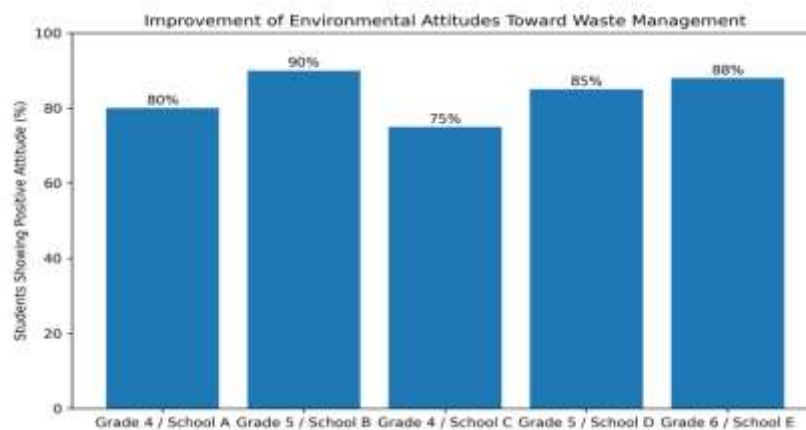


Fig. 5. Observation Results Implementation

From the figures, it is evident that understanding improved based on pretest and posttest scores. Waste Literacy. Most students show significant improvement in their understanding. Attitude is rated using the sheet observation and the questionnaire, including students' actions to manage waste. Qualitative data in the form of notes on the activity of students during the game. Students are generally enthusiastic and involved, active, even though there is a slight constraint in understanding the rules early in class (see below). Revision done for an adaptive level difficulty game for age students. Add an element, such as a card action, to motivate students to practice literacy directly.

E. Evaluation

At the stage evaluation, we will conduct data analysis to assess the improvement in students' literacy after playing Uwuhpoly. Evaluation was done by analyzing pretest and posttest data, as well as results observation during Implementation. Based on the evaluation results, the game was revised to improve effectiveness and quality. The final result, the game Uwuhpoly, is ready to be used as a learning medium for Waste Literacy. The pretest and posttest results are presented in Fig. 7.

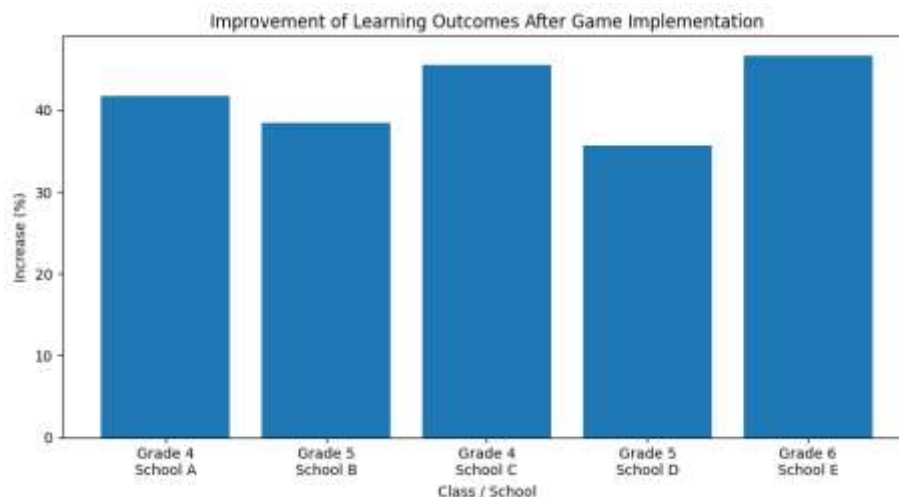


Fig. 6. Evaluation data pretest and pretest Waste Literacy in elementary school children

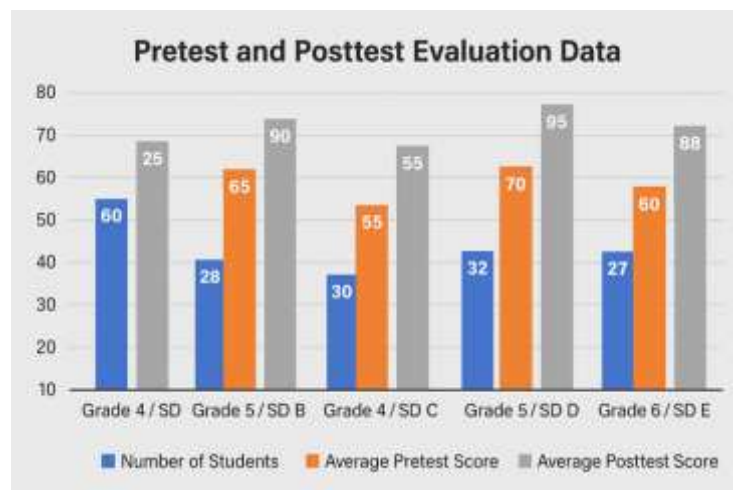


Fig. 7. Evaluation Data Pretest and Posttest Waste Literacy in Elementary School Children

Measure students' literacy understanding before and after playing at Uwuhpoly, or conduct a pretest and a posttest. Improvement was significant in all classes, with the highest average increase in grade 6 (46.7%). Noting the interaction of students during games, participation, and response to the game. The revision was based on pretest, posttest, and observation data

to improve the effectiveness of the games. Focus on simplification rules, addition of interesting elements (eg, card action), and adjustment of game time in accordance with the level class.

Discussion

The findings of this Study indicate that the Uwuhpoly educational game demonstrates high feasibility as a learning medium for environmental literacy in elementary schools. The expert validation results showed an average score of 4.51, placing it in the very valid category. This result suggests that the design, content relevance, clarity of rules, and attractiveness of the game meet the criteria required for instructional media in classroom learning. High validation scores indicate that the components of the game—including learning objectives, instructional structure, and gameplay mechanics—are aligned with educational purposes and can support meaningful learning experiences for students. The effectiveness of the Uwuhpoly game is further reflected in the implementation results. The data show a substantial increase in students' waste literacy scores, with pretest–posttest improvements ranging from 35.7% to 46.7%, and an overall effectiveness of approximately 85%. These results suggest that the game-based learning approach enables students to understand waste management concepts better and apply them in the contextual situations presented during gameplay. Through the game mechanics, students interact with scenarios related to sorting waste, recycling practices, and environmental responsibility, thereby actively engaging with the learning material. This improvement indicates that using an interactive board game can facilitate students' understanding of waste-related concepts and practices [40].

During the implementation process, students demonstrated active participation, enthusiasm, and engagement in discussions on waste management. These observations suggest that the learning process became more meaningful when students were directly involved in problem-solving situations represented in the gameplay [41], [42]. From a theoretical perspective, the results can be interpreted through the lens of constructivist learning theory, which posits that learners construct knowledge through interaction with experiences and social environments [43]-[45]. In the Uwuhpoly gameplay process, students were not merely receiving information; they were actively exploring scenarios related to waste sorting, recycling, and environmental responsibility. Through discussion and interaction with peers, students collaboratively built their understanding. This process reflects the principle that knowledge construction occurs through experiential engagement and reflection. The structure of the game also aligns with the concept of environmental literacy, which encompasses awareness, knowledge, attitudes, and action [8], [14]. The data obtained in this Study illustrate this progression. Students initially demonstrated limited understanding of waste management concepts, as reflected in the pretest scores. Through participation in the game, they encountered various environmental scenarios that required decision-making and

reflection [46], [47]. The increase in posttest scores indicates that the gameplay supported the development of conceptual understanding. At the same time, classroom observations revealed that students expressed positive attitudes toward environmentally responsible behaviors, such as separating waste and reducing plastic use [44], [48]-[51]. The integration of local environmental contexts within the game design also played an important role in facilitating students' understanding. Elements such as the garbage bank system and community waste management practices were incorporated into the gameplay scenarios. According to the principles of place-based learning, learning experiences that are connected to students' local environments can enhance relevance and comprehension. When students recognize familiar situations within the learning material, they are more likely to relate the knowledge gained in the classroom to real-life situations in their communities [52]. The results also indicate differences in how students from different grade levels interacted with the game. Younger students required more guidance from teachers and sometimes struggled to understand certain game mechanics. This finding suggests that instructional support and simplified rules are important for younger learners. In contrast, older students demonstrated greater independence during gameplay and were able to engage with more complex environmental scenarios. These observations indicate that educational game design should consider students' cognitive developmental stages to optimize learning outcomes [53]-[56].

Despite these positive findings, this Study has several limitations. First, the Implementation of the game was conducted within a limited number of schools and participants, which may restrict the generalizability of the findings. Second, the evaluation of learning outcomes was primarily based on short-term pretest and posttest measurements, which may not fully capture long-term behavioral changes in waste management practices. Third, the Study relied partly on observational data to assess student engagement, which may involve subjective interpretation. Future studies may benefit from involving larger sample sizes, longer observation periods, and additional measurement instruments to provide a more comprehensive understanding of the long-term impact of educational games on environmental literacy. Overall, the findings of this Study indicate that *Uwuhpoly* has the potential to serve as an effective learning medium for introducing waste literacy concepts to elementary school students. Through interactive gameplay, contextual learning content, and collaborative participation, the game facilitates meaningful learning experiences that foster environmental awareness and understanding among young learners.

Conclusion

Scientifically, this Study highlights the potential of contextual game-based learning as an effective pedagogical strategy for strengthening environmental literacy at the elementary level. By combining experiential learning, collaborative interaction, and environmental context,

Uwuhpoly facilitates meaningful learning experiences that connect conceptual knowledge with real-life environmental awareness. Future research should examine the long-term impact of such learning media on students' environmental behaviors and explore broader Implementation across different educational contexts. In addition, the development of digital or hybrid versions of Uwuhpoly may enhance accessibility and scalability, supporting the advancement of innovative environmental literacy learning models in elementary education.

Conflict of Interest

The authors declare no conflict of interest.

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