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Interactive Learning for Water Pollution Awareness: A Game-Based Approach

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Abstract

This research explores the potential of interactive educational games as a tool to enhance environmental literacy, with a specific focus on water pollution issues. The study introduces a designed game encompassing various interactive modules, such as word games, drag-and-drop tasks, multiple-choice questions, evaluations, and an environmental literacy survey. The validation test was carried out by three validators consisting of material expert lecturers and media experts. The average rcount value for validation test results across material aspects, language aspects, and display (media) aspects was calculated as follows: 0.85, 0.92, and 0.84, resulting in an overall rcount value of 0.87. This overall value signifies high validity and strong interpretational significance. Furthermore, the feasibility test was carried out on 15 chemistry education students who had taken environmental chemistry courses. The average rcount of the feasibility test results from all aspects obtained a percentage value of 87%. This study highlights the importance of game design, evaluating long-term impacts, and integrating interactive games into educational curricula.

1. Introduction

The environment is where living things carry out their life activities. However, when humans engage in excessive activities to fulfil their requirements, it leads to detrimental effects on the environment. There are many environmental problems facing society today, especially those related to water pollution. One notable concern pertains to the contamination of rivers due to the disposal of garbage and household waste. This contamination stands as a primary factor contributing to the scarcity of clean water sources [1, 2].

Water pollution is a change in conditions in a water reservoir such as lakes, rivers and oceans due to the entry of certain organisms or substances that cause a decrease in water quality [3, 4]. For example, in Indonesia, a case of water pollution that occurred in Kupang River, Indonesia which receives a combination of domestic, agricultural, and industrial waste, along with the effects of residential expansion. These factors collectively contribute to a decline in the quality of the river's water that can be seen from changes in the color and smell of the water, although some riverbank residents still use the Kupang River water for their daily needs [5]. Another example can be observed with the Krukut River, Indonesia. According to the 2017 Regional Environmental Management Performance Information Document (DIKPLHD), the water quality status of the Krukut River is

classified as lightly to moderately polluted. Despite this classification, the river continues to contribute around 5% of the total drinking water standards for DKI Jakarta, as reported by the Central Bureau of Statistics of DKI Jakarta in 2015. These shows that the management of environmental issues within Indonesian communities continues to raise concerns, resulting in a variety of environmental problems. Indonesian society's environmental literacy is still low, including concern for the environment. Environmental literacy is very important to mitigate various types of environmental damage, especially those caused by human activities [6].

Environmental literacy refers to the ability to comprehend and interpret environmental situations that allows a person to choose the best course of action to preserve their environment. This awareness of preserving the environment can also be seen as an attitude of environmental literacy that reflects the ability to solve environmental problems and have an understanding of the environment [7]. A person's level of environmental literacy can be assessed based on components of environmental literacy including knowledge, cognitive skills, attitudes, and responsible behavior [8].

Numerous studies explore the role of environmental education in enhancing environmental literacy. According to Hayati [9], the lack of environmental education for the general public to preserve environmental ecosystems is one of the causes of low environmental literacy. A study conducted by Maslamah et al. [10] highlights the importance of environmental education from an early age, so that every child can develop a sense of responsibility for the environment from an early age and then apply this knowledge in a way that preserves the environment.

Furthermore, it's becoming increasingly clear that students should develop environmental literacy. To address this need, various tools and methods are available, with learning media being one effective option. Learning media is a technology that facilitates the provision of content during teaching and learning activities. It can also be used alone to help students prepare and receive content [11]. Learning media comes in diverse formats, including textbooks, videos, interactive simulations, online modules, and more. However, one particularly popular format is educational games. These games are well-received because they have the dual advantage of being engaging and enjoyable, capturing students' interest and motivating their active participation [12, 13].

In recent years, several studies have been conducted to explore the effectiveness of educational games as a learning media. Sousa Lima et al. [14] conducted a study focusing on android-based games in the field of chemistry. Their study highlighted that smartphone have the capacity to greatly improve chemistry learning. Sulistyaningsih et al. [15] found that in their study, 71.4% of students find pleasure in using games as a means to learn chemistry because they can inspire and generate interest in learning for students. Similarly, Fitriana [16] observed an increase in student engagement in learning chemistry through the application of gaming media.

Interestingly, even though educational games are becoming more popular for learning, there's still a gap in creating interactive games that focus on water pollution problems. The aims of this study are to design educational games with a focus on water pollution, aiming to enhance students' environmental literacy. The primary goal is to create an interactive and captivating platform that enables students to comprehensively grasp the complexities of water pollution, including its various challenges and potential remedies.

2. Methods

The study used design-based research (DBR) and followed the Analysis, Design, Development, Implementation, Evaluation (ADDIE) model. ADDIE is a straightforward and user-friendly learning system design model that offers a structured approach to creating effective learning experiences [17]. However, this study was conducted up to the development stage, as its aim was to create learning media for water pollution material.

During the product design phase, a comprehensive flowchart is created to map out the game's entire sequence, followed by a descriptive storyboard based on this flowchart. In the development phase, the process begins with crafting game components using the "Articulate Storyline 3" software. Subsequently, a validation test is conducted involving subject matter expert lecturers and a media expert lecturer. Their feedback, gathered through questionnaires, guides the game's revision to better align with students' needs concerning water pollution material.

In this study the types of data generated are qualitative data and quantitative data. Qualitative data were obtained from the results of validation test questionnaires obtained from subject matter expert lecturers and media expert lecturers, then due diligence questionnaires were obtained from students who had taken environmental chemistry courses.

Table 1. Interpretation of the Validation Test

Eligibility Value (r)	Interpretation
0,80 ≥ r ≤ 1,00	High
0,60 ≥ r ≤ 0,80	High enough
0,40 ≥ r ≤ 0,60	Little low
0,20 ≥ r ≤ 0,40	Low
0,00 ≥ r ≤ 0,20	Very low

Table 2. Percentage of due diligence

Percentage (%)	Qualification
90-100	Very worth it
80-89	Decent
70-79	Decent enough
60-69	Not worth it
<60	Very unworthy

In this study, data was gathered through questionnaires or surveys [18]. The questionnaire employed was a validation test tool aimed at obtaining expert evaluations of the game under development. These evaluations serve as references for enhancing the game's quality.

To determine data validity, the collected information from the research subjects was compared to the data reported by the researcher. This validation is confirmed when the rcount value surpasses a critical threshold (rcount > 0.3), as outlined by Sugiyono [19]. During validation processing, a formula is applied to calculate the feasibility value (r). This formula to assess the reliability and validity of the collected data is presented in equation 1.

$$r = \frac{x}{N.n} \quad (1)$$

Where r represents the feasibility value derived from the accumulation of respondent-specific answer weights, denoted as x. These computations are drawn from a comprehensive pool of n respondents who participated in the study. It's worth noting that the highest achievable score is symbolized by N. The interpretation of the validation test score shown in Table 1.

To generate assessment data, along with comments and suggestions from students concerning the practicality of the developed games, the due diligence questionnaire is employed. This assessment tool categorizes responses into levels such as Strongly Agree (SS), Agree (S), Simply Agree (CS), Disagree (TS), and Strongly Disagree (STS). These categorizations are determined based on the percentage result obtained through the calculation using equation 2.

$$(\%)result = \frac{total\ score\ obtained}{maximum\ score}\ x\ 100\% \quad (2)$$

The interpretation value in the due diligence test is presented in Table 2.

3. Results and Discussions

3.1. Interactive Game Design

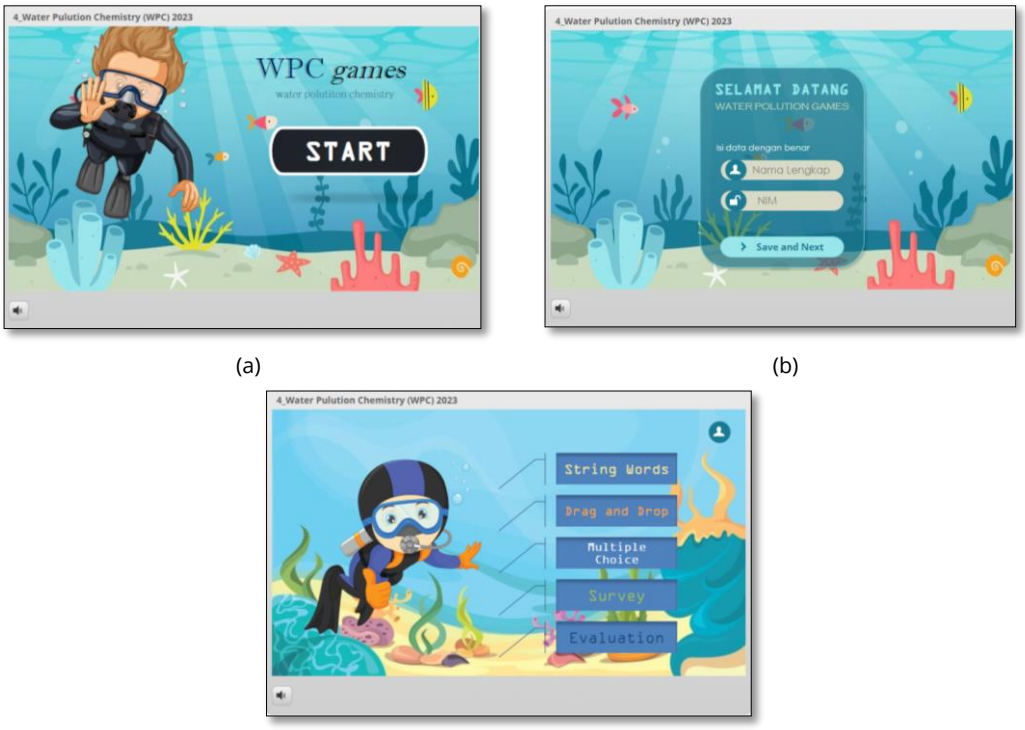
The game encompasses five distinct game types: string words, drag and drop, multiple choice, evaluation, and environmental literacy surveys.

Across these five game types, users have the opportunity to amplify their understanding and memory retention, serving as an evaluative tool for assessing the learning process related to water pollution themes. Furthermore, the game integrates a results scoreboard showcasing users' accrued points. It also encompasses engaging and challenging game rules, designed to captivate and challenge users at all gameplay stages.

The flowchart materializes as a visual representation guiding the game's unfolding. This sequential depiction encompasses several key junctures aligned with the game's progression. It initiates with the "Start" phase, signifying the game's commencement. Subsequently, users are prompted to provide their personal information, followed by accessing the game's menu. The menu offers two fundamental options: "Profile Generation" and "Game Selection."

Each game interface comprises multiple segments, commencing with the initialization phase, followed by inputting user-specific data, navigating through menus, crafting user profiles, and accessing the array of available games. These games encompass String Words, Drag and Drop, Multiple Choice, Evaluation, alongside an Environmental Literacy Survey intended to assess respondents' competency levels. Details of the relationship between game choices and question indicators are presented in Table 3.

The initial presentation of the game is illustrated in Figure 1. In Figure 1a, the introductory menu is showcased with a thematic focus on the "sea," aligning with the broader concept of "water." This display features the acronym "WPC," representing the game's title (Water Pollution Chemistry). Additionally, there is a prominent "Start" button, functioning as the navigational tool to initiate the application. Upon clicking this button, users are directed to the login page, depicted in Figure 1b. Here, players are required to input their personal information, specifically their full name and student identification number (NIM). The next menu (Figure 1c) offers players a range of five choices within the game. These options encompass three separate games, along with evaluation questions and an environmental literacy survey. The available selections



(a) (b)

(c)

Figure 1. The interface of the games; (a) initial view; (b) login page (c); game selection menu.

Table 3. Details the relationship between game choices and question indicators

Type game	literacy indicator	Cognitive Level	Σ Question
String words	Knowledge	C1	4
		C2	4
Drag and Drop	Cognitive skills (process)	C4	2
Multiple choice	Knowledge	C1	2
		C2	2
	Cognitive skills (process)	C3	1
		C4	3
		C5	1
	Attitude	C4	1
Literacy Survey	Attitude	7	3
	Action	9	1
Evaluation	Knowledge	C1	10
		C2	9
	Cognitive skills (process)	C2	1
	Attitude	C2	1
	Cognitive skills (process)	C3	1
	Action		3
	Knowledge	C4	4
	Cognitive skills (process)	C5	1

consist of "String Words," "Drag and Drop," "Multiple Choice," the "Environmental Literacy Survey," and an "Evaluation" section.

The "String Words" component involves a series of words with arranged letters that require players to place them into designated boxes. This game segment comprises eight questions that players must successfully address. Importantly, participants are required to complete all ten available questions before exiting the game. This game segment is complemented by a comprehensive game results report that includes a "Quiz Review" section. Within the "Quiz Review," players can ascertain which answers were correct or incorrect. Additionally, an "Answer Key" is provided, allowing players to cross-reference and confirm the correct responses. For further engagement, a "Retry Quiz" option is available, enabling players to undertake the game anew.

Table 4. The average validation test results.

Rated aspect	r_{count}	$r_{critical}$	Conclusion	Interpretation
Material	0.85	0.3	Valid	High
Language	0.92	0.3	Valid	High
Media	0.84	0.3	Valid	High
Average	0.87	0.3	Valid	High

Drag and Drop is the second game which contains two questions that must be completed by the player. This game contains matching pictures with the words provided, but before starting this game the player is given the opportunity with a predetermined time limit to remember the picture in question complete with picture instructions after that the slide will move by itself to the first question, in this game the results are also given as a report on the results of the games that have been played.

The third game contains multiple choice with ten available questions, in this game the player is required to choose one answer that he feels is correct, and then given a result which shows the score obtained by the player. Players can see the review after completing all the available questions with the aim of seeing which answers are right or wrong when playing it.

The environmental literacy survey contains points distributed to respondents to determine the level of environmental literacy of the respondents, which can be seen from the indicators of environmental literacy, namely the attitudes and actions of respondents towards the environment in the problem of water pollution.

Evaluation questions consist of 30 questions that can be accessed by players with the aim of increasing understanding of water pollution material, equipped with scores and reviews so that we can see the score obtained after completing the available questions and can also find out how far we can understand pollution material water, besides that this evaluation question can be used as a final assessment by the teacher because it can give the value obtained by the participants who work on this evaluation question.

3.2. Validation Test Analysis Results

The validation test phase was carried out by three expert validators consisting of two material experts and one media expert. The purpose of this validation test is to evaluate the initial quality of environmental literacy-oriented interactive games on water pollution material and to get suggestions for improvement in terms of presenting aspects of the material content, language, and appearance, so as to create valid games in the form of products to be used as learning media. The average results of the validation test are presented in Table 4.

In the validation test, all aspects were found to be valid, achieving an average score of 0.87 with a high interpretation category. Additionally, valuable feedback for enhancement was gathered from validators. This feedback, consisting of qualitative data, included suggestions and comments aimed at refining the quality of the products that were developed.

3.3. Due Diligence Results

Due diligence is carried out after the product is declared valid in all respects. The product feasibility test was carried out on a simple scale with 15 respondents, namely chemistry education students who had taken environmental chemistry courses. The purpose of this due diligence is to determine whether interactive games on environmental literacy-oriented water pollution materials can be used as classroom learning tools. And the feasibility test results are obtained in Table 5.

Table 5. The average due diligence results.

Total Score	Maximum Score	Σ	%	Qualification
65.95	75	0.87	87%	Worthy

The overall due diligence results have an average percentage of 87% in all aspects. So interactive games oriented to environmental literacy on water pollution material are included in the appropriate category, so this interactive game can be used as a learning medium to support chemistry learning in particular, and for society in general, especially on water pollution material. This is in accordance with the opinion of Helsy & Andriyani, (2017) which states that the learning media used must be interesting and easy for students to understand. Overall, this environmental literacy-oriented game on water pollution material can be declared fit for use as a learning media.

4. Conclusions

This study has demonstrated that interactive educational games can effectively improve people's understanding of environmental issues, especially water pollution. The designed game, which includes different activities like word games, drag-and-drop tasks, multiple-choice questions, evaluations, and an environmental knowledge survey, has shown to be a valuable tool for engaging learners and enhancing their grasp of complex

environmental topics. The assessments carried out to validate and test the game have confirmed its quality and suitability for educational settings, highlighting its potential to raise environmental awareness and promote informed decision-making. This study emphasizes the importance of integrating technology and game-like elements into education, as a way to effectively address environmental challenges. However, more study is needed to improve the game designs, measure long-term impacts, and explore how these games can be better integrated into education.

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