Journal of Ecohumanism
2025
Volume: 4, No: 2, pp. 320 – 339
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v4i2.6007

Exploring the Impact of Computer RPG Game-Based Teaching Modules on Environmental Education for Eighth-Grade Junior High School Students

Yi-Lin Hsieh[1], Shin-Cheng Yeh[2]

Abstract

This study aims to explore the changes in the cognition, attitudes, and behaviors of eighth-grade students regarding environmental and marine conservation after being taught using a computer-based RPG (Role-playing game) instructional module. The participants were divided into an experimental group and a control group. The control group received traditional instruction, while the experimental group used a course module designed for this study. This module was adapted based on the concept of the Fish Banks game, and the researcher developed a computer RPG game called "Ocean Domination" for the instruction. The results of the study revealed that, among the five environmental education competency indicators, the experimental group, which used the computer RPG game-based instructional module, showed significant improvement in environmental awareness and sensitivity, environmental conceptual knowledge, and environmental action experience. In contrast, the group that used traditional instruction did not show significant progress. Both groups exhibited significant improvement in environmental values and attitudes, as well as environmental action skills, with the experimental group's progress being higher than that of the traditional instruction group. Additionally, the experimental group demonstrated a significant improvement in interest in environmental course learning, whereas the traditional instruction group did not. In summary, the computer RPG game-based instructional module developed in this study had a positive impact on the cognition, affect, and skills of eighth-grade students in terms of environmental conservation.

Keywords: *RPG Game-Based Instruction, Fish Banks, Environmental Education, Marine Education Curriculum, Sustainable Education.*

Introduction

Background

With the increasing global population and technological advancements, the exploitation and utilization of marine resources have garnered significant attention. However, overfishing has become a severe challenge, posing serious impacts on marine ecosystems and human livelihoods. As one of the largest ecosystems on Earth, the ocean provides abundant food and resources while regulating the planet's climate and oxygen supply. Nevertheless, the issue of overfishing has subjected marine ecosystems to unprecedented stress (Coll et al., 2008; Jackson et al., 2001).

The impacts of overfishing on marine ecosystems are multifaceted. Firstly, it disrupts ecological balance, leading to a sharp decline in certain species, which in turn affects the stability of the entire food chain. Secondly, overfishing influences the migration and reproduction of marine species, further reducing their population and biodiversity. Additionally, overfishing negatively impacts fisheries and coastal communities by diminishing opportunities for sustainable fishing and reducing basic income sources for these communities (Jönsson, 2019; Möllmann & Diekmann, 2012).

To address this pressing challenge, effective measures must be taken to resolve the issue of overfishing. Beyond policy formulation and enforcement by governments and international organizations (Kieves, 2004), education is also considered a crucial avenue. Through education, public awareness about overfishing can be enhanced, promoting changes in harmful fishing practices and encouraging participation in marine conservation and sustainable fishing efforts (Ghilardi-Lopes et al., 2019; Mokos et al., 2020).

Bloom's educational objectives are categorized into three domains: cognitive, affective, and psychomotor

[1] National Taiwan Normal University, Taipei, Taiwan, Email: 81046003S@ntnu.edu.tw (Corresponding Author)

[2] National Taiwan Normal University, Taipei, Taiwan, Email: scyeh@ntnu.edu.tw

Journal of Ecohumanism
2025
Volume: 4, No: 2, pp. 320 – 339
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v4i2.6007

(Bloom, 1969). Similarly, the environmental education curriculum objectives outlined in the Ministry of Education's 9-Year Curriculum Guidelines include five components: environmental awareness and sensitivity, environmental conceptual knowledge, environmental ethics and values, environmental action skills, and environmental action experience. These aim to empower students to make informed and balanced decisions and actions that consider ecological, economic, and sustainable development perspectives.

In recent years, to achieve teaching objectives across various disciplines, game-based teaching methods and digital technologies have often been integrated into teaching practices. Numerous studies have shown that game-based learning or digital-assisted teaching activities are more effective in engaging students, enhancing their motivation, and improving learning outcomes compared to traditional teaching methods (Hu et al., 2007; Tobias et al., 2014). However, in the context of environmental education, research on using digital game-based learning to simultaneously achieve cognitive, affective, and psychomotor learning goals while fostering students' interest in environmental education remains limited.

In response, this study develops a digital game-based learning module aimed at helping students achieve these learning objectives.

Research Questions

This study seeks to answer the following six research questions:

How does computer RPG game-based teaching influence students' environmental awareness and sensitivity?

How does computer RPG game-based teaching influence students' environmental conceptual knowledge?

How does computer RPG game-based teaching influence students' environmental action experience?

How does computer RPG game-based teaching influence students' environmental values and attitudes?

How does computer RPG game-based teaching influence students' environmental action skills?

How does computer RPG game-based teaching influence students' interest in environmental education courses?

Literature Review

Game-Based Learning

Game-based learning integrates game elements and design principles into educational and learning activities to enhance learners' engagement, motivation, and learning outcomes. This instructional approach leverages game characteristics such as challenges, instant feedback, interactivity, and goal setting, making the learning process more enjoyable, engaging, and effective (Ifenthaler et al., 2012; Plass et al., 2015; Qian & Clark, 2016; Shi & Shih, 2015; Tobias et al., 2014).

The definition of game-based learning encompasses multiple aspects, including "game elements," "learning objectives," "engagement motivation," and "instant feedback and challenges." Therefore, game-based learning requires designing an educational game that integrates instructional content with game features. This type of game immerses participants in a cycle of judgment, execution, and feedback in response to challenges, ultimately achieving specific learning goals. Some scholars suggest that incorporating computer games into learning activities can further enhance the efficiency of this cycle, thereby benefiting students' learning (Garris et al., 2002).

Application of Game-Based Learning in Environmental Education

Game-based learning in environmental education can take various forms (Koenigstein et al., 2020; Leitão et al., 2022; Plass et al., 2015; Torralba-Burrial & Dopico, 2023), such as simulated environmental teaching, ecological simulation games, environmental problem-solving games, resource management simulation games, and community engagement games. These formats allow students to actively participate in environmental education, improving their awareness and understanding of environmental issues.

In this context, game-based education is considered a promising teaching method that captures students' attention and enhances their understanding of environmental issues. The Fish Bank game, focusing on marine ecological conservation, has gained significant attention in the field of environmental education (Meadows et al., 1989).

Fish Bank is a strategy simulation game centered on marine ecological conservation. Players manage a virtual marine ecosystem, learning how to protect marine resources, balance ecological development, and prevent issues like overfishing. In the game, players formulate strategies, protect the marine environment, and address various challenges and threats. The game's interactivity and instant feedback provide players with an intuitive understanding of the fragility of marine ecosystems and strategies for effective conservation (Sala et al., 2016; Weines, 2021).

Research shows that the Fish Bank game is effective in environmental education (Weines, 2019). One study found that participating in the game significantly improved students' awareness and knowledge of marine conservation while fostering positive attitudes toward conservation behaviors. Additionally, the game helps develop students' problem-solving abilities and teamwork skills, promoting proactive environmental protection actions (Śnieżyński & Koźlak, 2005).

This study incorporates various formats, drawing on the design philosophy of the Fish Bank game. It develops an RPG-style digital game and instructional module where students experience changes in marine resources under overfishing scenarios within a virtual world. The game simulates ecosystem operations, allowing students to deeply understand the impact of human activities on ecosystems and devise game-based solutions to specific environmental issues. It challenges students to navigate dilemmas between economic development and overfishing, fostering critical thinking about these problems.

Studies on Marine Ecosystems and Overfishing

Overfishing impacts marine ecosystems by altering species composition and diversity, disrupting ecological balance, and affecting marine organisms' migration and reproduction (Boonstra & Österblom, 2014; Jackson et al., 2001; Murawski, 2000). Contributing factors include overfishing practices, inadequate fisheries policies, and illegal fishing.

In 1987, the World Commission on Environment and Development (WCED) defined sustainable development in Our Common Future as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland, 1987). In 2015, the United Nations launched the "2030 Sustainable Development Goals" (SDGs), including 17 core goals. Among these, SDG 14, "Life Below Water," emphasizes conserving and sustainably using marine ecosystems to ensure biodiversity and prevent degradation.

Target 14.4 of SDG 14 calls for effectively regulating fishing activities to end overfishing, illegal, unreported, and unregulated (IUU) fishing, and destructive fishing practices by 2020. It also aims to restore fish stocks to sustainable levels as quickly as possible. Target 14.7 seeks to enhance the economic benefits of sustainable marine resource use for small island developing states (SIDS) and least developed countries (LDCs) by 2030, focusing on sustainable fisheries, aquaculture, and tourism. Sustainable fisheries management is crucial for conserving marine ecosystems.

However, addressing overfishing requires integrating other SDGs, such as SDG 1 (No Poverty), SDG 2

(Zero Hunger), SDG 4 (Quality Education), SDG 12 (Responsible Consumption and Production), and SDG 17 (Partnerships for the Goals) (Brooks, 2016; Cepal, 2016; Koutouki & Phillips, 2016). This study focuses on developing curriculum content that fosters decision-making and actions balancing ecological, economic, and sustainable development considerations.

Evaluating the Effectiveness of Game-Based Education

Research indicates that game-based learning has positive effects on students' learning. First, students engaged in game-based teaching achieve better learning outcomes (Kirriemuir & McFarlane, 2004). Compared to traditional methods, game-based learning enhances memory retention of knowledge concepts (Hogle, 1996). Second, game-based teaching stimulates learning motivation. Elements such as curiosity, expectation, control, interactivity, and narrative fantasy in games increase learners' interest and intrinsic motivation. Learners are more willing to persist through challenges, enhancing their motivation to learn (Divjak & Tomić, 2011; Huizenga et al., 2009; Mattheiss et al., 2009; Partovi & Razavi, 2019). Third, game-based learning fosters higher-order thinking. When instructional content is embedded in games, learners solve problems and make decisions, requiring them to integrate their knowledge to find solutions (Cicchino, 2015; Mao et al., 2022).

Environmental Behavior Theory

Traditional educational theories often assume that providing students with environmental knowledge can change their environmental behaviors. Some studies suggest that increased knowledge leads to the formation of appropriate attitudes, which drive actions to improve environmental quality, forming a behavior change system (Hungerford & Volk, 1990). However, meta-analyses reveal multiple variables influencing environmental behavior. Hines (1987) proposed the "Model of Responsible Environmental Behavior," identifying that individuals' intention to act stems from prerequisites such as knowledge of strategies, action skills, and environmental issues. With these background conditions, coupled with attitudes and a sense of responsibility, individuals are empowered to take environmental action (Hayward, 1990; Hines et al., 1987).

Environmental actions, influenced by various factors, include five categories: persuasion, consumption behavior, ecological management, legal actions, and political actions (Alisat & Riemer, 2015; Ramsey et al., 1981). This study's scale for assessing students' environmental actions is based on these five categories.

Research Methodology

Research Subjects

The subjects of this study were eighth-grade students from a junior high school in Zhubei City, Hsinchu County. The school enrolls approximately 400 students per grade level. Excluding specialized arts and athletic classes, the remaining classes are organized using an "S-curve" method for normal distribution grouping. The school emphasizes science education as its core curriculum, achieving outstanding results in science fairs, competitions, and academic advancement. It is also recognized as a model school for environmental education in Hsinchu County.

The researcher selected four classes as the study sample. Using classes as units, random selection was conducted to form an experimental group and a control group, each comprising two classes, for a total of 117 students. The experimental group participated in the RPG computer-based Fish Banks game-based learning, while the control group received traditional teaching methods.

Research Tools

The Environmental Education Curriculum Evaluation Scale was designed to assess changes in students' cognition, affective domains, and skills related to marine conservation, environmental conservation, and sustainable development. The scale includes six subscales that independently measure:

Journal of Ecohumanism
2025
Volume: 4, No: 2, pp. 320 – 339
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v4i2.6007

Environmental awareness and sensitivity

Environmental conceptual knowledge

Environmental values and attitudes

Environmental action skills

Environmental action experiences

Interest in environmental curriculum

The evaluation adopts a five-point Likert scale (Joshi et al., 2015), with responses ranging from "Strongly Agree" to "Strongly Disagree." The scale demonstrated good reliability, with a Cronbach's α value of 0.829. A sample of the scale is presented in Table 1.

Table 1. Sample Questionnaire Items

Instruction: Since starting junior high school, and before completing this questionnaire, select the option that best reflects your situation. Please mark the appropriate box (✓).

	Strongly Agree(5) Strongly Disagree(1)				
A1. I care about the depletion of fishery resources around Taiwan.	5	4	3	2	1
A2. I feel worried or sad about overfishing.					
A3. I think the depletion of fishery resources is distant from my life, and I don't care about it.					
A4. I feel angry when I see fishermen using illegal gillnets.					
A5. I feel sad when I see fishermen using illegal gillnets.					
A6. I feel worried when I see fishermen using illegal gillnets.					
A7. I am interested in understanding the reasons for the depletion of Taiwan's fishery resources.					
A8. I am interested in learning how to achieve sustainable development of fishery resources.					
B1. I believe that when the government formulates fishery policies, it should establish fishery conservation zones as sustainable natural resources.					
B2. I believe environmental conservation is more important than economic development.					
B3. I think restoring marine fishery resources is time-consuming and ineffective.					
B4. I think not restricting fishing seasons has little impact on ecology.					
B5. I think drifting garbage in the sea is not a serious issue.					
C1. I will reduce the frequency of eating fish to contribute to the sustainability of Taiwan's fishery resources.					
C2. I will reduce the frequency of eating whitebait to avoid catching juvenile fish.					
C3. When I go shopping for fish with my family, I will advise them not to buy small fish.					
C4. I will share information about the depletion of fishery resources with others.					
C5. When someone I know eats whitebait, I will try to persuade them not to.					
C6. If I discover fishermen using illegal gillnets, I will report them.					

Journal of Ecohumanism
2025
Volume: 4, No: 2, pp. 320 – 339
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v4i2.6007

C7. I will participate in marine conservation-related service-learning courses.					
C8. I will comply with environmental regulations to maintain sustainable environmental resources.					
C9. If there is no fish to eat in 20 years, I will do my best to mitigate fishery depletion.					
C10. If there is no fish to eat in 20 years, I want to learn ways to mitigate this issue.					
C11. When I go to the beach, I will carefully maintain the environment.					
C12. When I go to the beach, I will take garbage away to prevent environmental pollution.					
D1. I understand issues related to fishery resource conservation.					
D2. I know what a fishermen's association is (its functions and how it generates revenue).					
D3. I understand the pricing mechanism of fish markets.					
D4. I know how the use of gillnets leads to marine ecological damage.					
D5. I understand how small mesh sizes in fishing nets contribute to marine ecological damage.					
D6. I know the environmental impact of bottom trawling on the marine ecosystem.					
D7. I know that overfishing is one of the causes of insufficient marine fishery resources.					
D8. I understand the auction system in fish markets.					
D9. I understand the operational costs of fishing boats.					
D10. I understand the reasons behind the overfishing practices of fishing boats.					
E1. I enjoy formal physics and chemistry lessons in natural science classes.					
E2. I enjoy environmental conservation lessons in natural science classes.					
	times				
	≥4	3	2	1	0
F1. I finish reading news and articles related to Taiwan's environment.					
F2. I finish reading news and articles related to Taiwan's fisheries.					
F3. I have actively searched for news and articles about fisheries.					
F4. I have voluntarily engaged in activities to protect Taiwan's fishery resources.					
F5. I have voluntarily engaged in activities to protect Taiwan's environment.					
F6. I participate in beach cleanup activities.					
F7. I want to learn behaviors that can protect the environment.					
	Always -<------ >Never				
F8. I avoid taking plastic bags from stores when I shop.					
F9. I turn off the lights when they are not needed.					
F10. I minimize air conditioning usage when it is unnecessary.					

As shown in Table 2, each question corresponds to a specific assessment dimension. To enhance the content validity of this questionnaire, feedback and suggestions were sought from domestic experts, scholars, and four natural science teachers with 15 to 20 years of teaching experience in biology, earth science, and physics and chemistry at secondary schools. These experts reviewed and evaluated the appropriateness of each question to ensure content validity. Ambiguities in phrasing or unclear causality in certain questions were revised accordingly.

Journal of Ecohumanism
2025
Volume: 4, No: 2, pp. 320 – 339
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v4i2.6007

Table 2. Correspondence Between Question Numbers and Assessment Dimension Descriptions

Question Numbers	Number of Questions	Assessment Dimension Description
A1–A6	6	Evaluates participants' environmental awareness and sensitivity.
B1–B5	5	Evaluates participants' environmental values and attitudes.
C1–C9, C11–C12	11	Evaluates participants' environmental action skills, categorized into: consumerism (C1–C3), persuasive action (C4–C5), ecological management (C7–C9, C11–C12), and legal action (C6).
D1–D10	10	Evaluates participants' environmental conceptual knowledge.
F1–F10	10	Evaluates participants' environmental action experiences.
A7–A8, C10, E2	4	Evaluates participants' interest in learning about environmental courses.

Table 3. Cronbach's Alpha Values and Number of Items for Each Dimension

Dimensions of Environmental Education	**Cronbach's Alpha**	**Number of Items**
Students' Environmental Awareness and Sensitivity	0.667	6
Students' Environmental Conceptual Knowledge	0.825	10
Students' Environmental Values and Attitudes	0.671	5
Students' Environmental Action Skills	0.812	11
Students' Environmental Action Experiences	0.794	10
Students' Interest in Environmental Education	0.633	4

Note: No Cronbach's Alpha value for individual items in any dimension exceeds the corresponding value for the entire dimension by more than 0.1.

The Environmental Education Curriculum Evaluation Questionnaire consists of six sub-questionnaires designed based on different competency indicators, aiming to assess six key competencies in environmental education. To ensure the reliability of each dimension, all sub-questionnaires corresponding to these competencies were analyzed using the statistical software IBM SPSS Statistics 22. Table 3 presents the Cronbach's Alpha values and the number of items for each dimension.

Explanation of Computer-Based RPG Game Courses

Principles of Game Design and Gamification

Game-based learning incorporates various characteristics, such as entertainment, playfulness, rule-based structure, goal orientation, human-computer interaction, feedback and results, adaptability, a sense of achievement, conflict and competition, challenge, problem-solving, social interaction, and visual storytelling (Prensky, 2005).

In the field of educational technology, digitalized game-based learning is becoming increasingly prevalent (Becker, 2007). Many scholars argue that digital game-based learning is emerging as a new paradigm in digital learning (Squire, 2005; Thomas, 2004).

Regarding the sense of conflict, competition, and challenge, competitive game-based learning represents one model of game-based learning. Several studies have indicated that competitive game-based learning generates high levels of positive interest. Quantitative results have shown that this learning model effectively encourages students to engage in online learning actively, with significant improvements in their learning outcomes. When competitive game-based learning is integrated with digital game-based learning, it forms a model known as competitive digital game-based learning.

2025
Volume: 4, No: 2, pp. 320 – 339
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v4i2.6007

Recent educational research has found that competitive learning approaches can increase learners' interest and effectiveness in learning, outperforming traditional teaching methods.

This teaching module is divided into three stages: the "Course Explanation Stage," the "Competition-Game-Assisted Course Development Stage," and the "Post-Competition Reflection Stage."

Course Explanation Stage

This stage includes two main components: random group assignments within the class and the introduction of rules, aligning with the challenge and rule-based structure of game design.

The competition involves five groups, each consisting of six students seated in proximity. The game rules are presented through a slideshow, and students are introduced to the rules as outlined in Table 4, which illustrates the corresponding rules and their explanations.

Table 4. Correspondence between Rules and Explanations

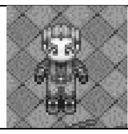
Rule Number	Rule Explanation
1	Each group starts with an initial fund of 10 million dollars. The goal to win the game is to earn 50 million dollars.
2	Each year, groups may purchase fishing boats, each costing 200,000 dollars. Boats are not subject to destruction after purchase. Starting from the year after purchase, each boat incurs a docking tax of 10,000 dollars annually.
3	Each year, groups decide how many boats to send out for fishing. The fish caught can be sold for profit.
4	For every boat sent out to fish, regardless of the catch, fuel costs are fixed at 10,000 dollars per boat.
5	The game ends when either a group achieves the target of 50 million dollars or all groups go bankrupt.

After explaining the rules, students are given 3 minutes for intra-group discussion to deliberate and devise game strategies. Following this, an additional 3 minutes is allocated for clarifying any student questions about the rules.

To enhance students' motivation to win and align with the goal-oriented and achievement-driven principles of game-based learning, the instructor supplements the course explanation by announcing that the first group to achieve the goal of earning 50 million dollars will receive an agreed-upon reward. This incentive strengthens the students' drive for competitive success.

Additionally, to incorporate the visual storytelling elements of game-based learning, each group is assigned a specific role in the game, as detailed in Table 5, which introduces the representative characters for each group's assigned role within the game narrative.

Table 5. Role Assignments and Character Illustrations for Each Group

Group	1	2	3	4	5
Representative Characters for Each Group in the Game					

*The game can be downloaded from the following URL. It is recommended to adjust the screen resolution for optimal gameplay. https://drive.google.com/file/d/13YPwEMd_TnqNF_7PRrRIbDOBm2x6eDxr/view?usp=sharing

Journal of Ecohumanism
2025
Volume: 4, No: 2, pp. 320 – 339
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v4i2.6007

Competition Game-Assisted Course Development Phase

This phase involves the competitive gameplay, which is divided into four sub-stages based on the game map design:

Fishing Boat Procurement and Deployment Stage

Fishing Expedition Stage

Catch Statistics Stage

Game End Stage

Fishing Boat Procurement and Deployment Stage

At the start of each round (representing one year), the game automatically displays the total bank balance of each group on all students' screens. Within three minutes, each group discusses and decides on the number of boats they wish to purchase and deploy for fishing during that round. Once finalized, all group members report their decisions to the instructor, who inputs the data into the game program and ensures accuracy (as illustrated in Figure 1). After all groups have submitted their decisions, the instructor controls the protagonist character to interact with the "Sailor NPC." The sailor prompts the groups to confirm their decision to proceed with fishing, and upon confirmation, the game transitions to the next stage

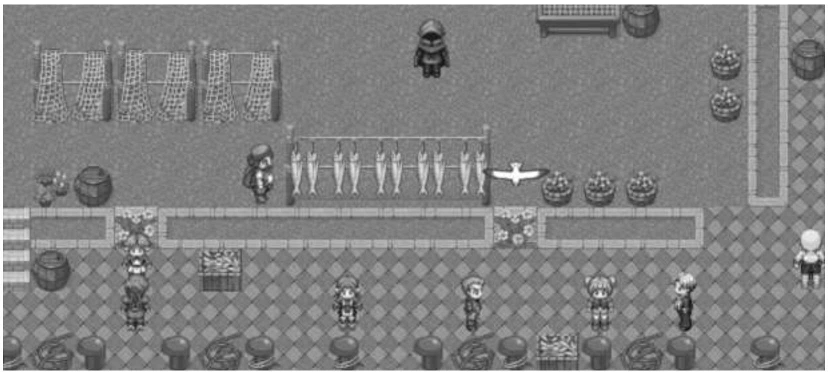


Figure 1. Groups Confirming the Number of Boats Deployed Per Round

Fishing Expedition Stage

This stage serves as a transitional scene, visualizing the fishing environment to simulate a realistic fishing scenario, enhancing students' immersion in the game-based course. During this stage, the game presents fragments of fisheries and environmental knowledge to the students, aiming to improve their understanding of marine and environmental concepts. For example, it may introduce traditional knowledge, such as "areas with many seabirds often indicate abundant fish."

Catch Statistics Stage

In this stage, the game automatically generates and displays the annual catch data on students' screens. The data includes:

Total number of fish caught during the year

Unit price of fish

Total catch and revenue for each group

Journal of Ecohumanism
2025
Volume: 4, No: 2, pp. 320 – 339
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v4i2.6007

The presentation of the annual fish count and unit price serves two purposes:

To help students understand the market mechanisms of the fishing industry through observation and the application of supply-and-demand principles.

To highlight the game's design of decreasing fish populations over time, encouraging students to adjust their competitive strategies accordingly, which aligns with the problem-solving aspect of game-based learning.

The presentation of group-specific catch and revenue serves two additional purposes:

To maintain the competitive nature of the game, immersing students in this marine dominance competition.

To allow students to observe how increasing the number of deployed boats does not guarantee proportional increases in fish caught, reinforcing the need for strategy adjustments.

During this stage, students are advised to record the data on paper for longitudinal analysis of fishing trends and inter-group comparisons. Once all groups have completed data recording, the game progresses to the next round, returning to the Fishing Boat Procurement and Deployment Stage, or continues until all groups go bankrupt due to excessive tax expenditures and dwindling revenues caused by overfishing.

Game End Stage

This stage displays the "GAME OVER" screen, announcing the end of the game and transitioning into the Post-Competition Reflection Phase.

Post-Competition Reflection Phase

The purpose of this phase is to encourage students to reflect on the competitive processes of the previous phase. The instructor highlights that, despite observing the phenomenon of declining fisheries resources, groups continued to deploy boats aggressively to win, with no effort to reduce or halt overfishing. Furthermore, no students took the initiative to negotiate or communicate with others to prevent unsustainable practices.

Using this as a foundation, students are guided to reflect on their behaviors, raising awareness of the causes of fishery depletion. This phase emphasizes the environmental consequences of resource exhaustion, fostering positive attitudes toward environmental conservation. It also aims to enhance students' problem-solving abilities and motivation to engage in eco-friendly actions when faced with environmental challenges.

Additionally, this phase introduces students to the metacognitive aspects of the game's design, such as the "sustainable development" and "no-fishing zones" options. This promotes an understanding of sustainable practices and environmental conservation, encouraging students to lead negotiations and communicate with others to prevent destructive behaviors.

Research Results and Analysis

Impact on Students' Environmental Awareness and Attitudes

Descriptive Statistics

Mean, Standard Deviation, Confidence Intervals, and Sample Size

The analysis of survey items A1–A6 regarding students' environmental awareness and attitudes is presented in Table 6 below.

Journal of Ecohumanism
2025
Volume: 4, No: 2, pp. 320 – 339
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v4i2.6007

Table 6. Descriptive Statistics for Environmental Awareness and Attitude Scale

Measurement Variable	*N*	Pre-Test			Post-Test		
		M	*SD*	*95%CI*	*M*	*SD*	*95%CI*
Control	49	3.53	0.49	[3.39,3.67]	3.51	0.47	[3.38,3.65]
Experimental	58	3.66	0.51	[3.53,3.79]	3.95	0.58	[3.79,4.10]
Total	107	3.60	0.50	[3.51,3.70]	3.75	0.57	[3.64,3.86]

Table 7. ANCOVA Summary for Post-Test Scores Across Groups

Dependent Variable Post-Test Scores	ANCOVA Summary for Post-Test Scores Across Group				
	SS	*df*	*MS*	*F*	*p*
Group	3.21	1	3.21	16.93	0.00**

Note: p < .05

Pre-Test t-Test:

From Table 6, the pre-test means of the control and experimental groups are 3.53 and 3.66, respectively. To examine whether there is a significant difference between the groups at the pre-test stage, an independent samples two-tailed t-test was conducted. The results showed that the t-value for environmental awareness and attitude was 1.37 with a p-value of 0.17 ($p > 0.05$), indicating no significant difference between the pre-test scores of the control and experimental groups.

ANCOVA Analysis

An ANCOVA was conducted to examine the relationship between groups and pre-/post-test scores. Post-test scores were used as the dependent variable, pre-test scores as the covariate, and group (control vs. experimental) as the fixed factor. The results of the ANCOVA are presented in Table 7.

The results indicate a significant effect of different teaching modules on the experimental outcomes, with a p-value of 0.00 ($p < 0.05$). This suggests that the teaching module had a significant impact on students' environmental awareness and attitudes.

The experimental group's participants, after engaging in competitive digital game-based learning, demonstrated better performance in environmental awareness and attitudes compared to the control group, which followed traditional teaching methods. Analysis revealed that the difference in group type had a significant impact on pre-test and post-test scores, leading to the conclusion that the experimental group's post-test performance was significantly better compared to their pre-test scores.

Impact on Students' Environmental Concept Knowledge

Descriptive Statistics

Mean, Standard Deviation, Confidence Intervals, and Sample Size

The analysis of survey items D1–D10 regarding students' environmental concept knowledge is presented in Table 8 below.

Journal of Ecohumanism
2025
Volume: 4, No: 2, pp. 320 – 339
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v4i2.6007

Table 8. Descriptive Statistics for Environmental Concept Knowledge

Measurement Variable	*N*	Pre-Test			Post-Test		
		M	*SD*	*95%CI*	*M*	*SD*	*95%CI*
Control	49	3.21	0.63	[3.03,3.39]	3.52	0.59	[3.35,3.69]
Experimental	58	3.19	0.59	[3.03,3.34]	3.84	0.51	[3.70,3.97]
Total	107	3.20	0.61	[3.08,3.31]	3.69	0.57	[3.58,3.80]

Pre-Test t-Test

As observed in Table 8, the pre-test means for the control and experimental groups are 3.21 and 3.19, respectively. To examine whether there is a significant difference between the groups at the pre-test stage, an independent samples two-tailed t-test was conducted. The results showed that the t-value for environmental concept knowledge was 0.22 with a p-value of 0.83 ($p > 0.05$). This indicates no significant difference between the pre-test scores of the control and experimental groups.

ANCOVA Analysis

An ANCOVA was conducted to examine the relationship between groups and pre-/post-test scores. Post-test scores were used as the dependent variable, pre-test scores as the covariate, and group (control vs. experimental) as the fixed factor. The results of the ANCOVA are presented in Table 9.

Table 9. ANCOVA Summary for Post-Test Scores Across Groups

Dependent Variable Post-Test Scores	ANCOVA Summary for Post-Test Scores Across Groups				
	SS	*df*	*MS*	*F*	*p*
Group	2.80	1	2.80	10.64	0.01**

Note: p < .05

The results indicate a significant difference in post-test scores between the control and experimental groups, with a p-value of 0.01 ($p < 0.05$). This suggests that different teaching modules had a significant impact on the post-test performance of students' environmental concept knowledge.

The experimental group participants demonstrated higher post-test performance in environmental concept knowledge compared to their pre-test performance after undergoing the environmental course instruction. Based on the analysis, it was found that the different teaching methods between groups had a significant impact, leading to the conclusion that the experimental group's post-test results were significantly better than their pre-test results.

Impact on Students' Environmental Values and Attitudes

Descriptive Statistics:

Mean, Standard Deviation, Confidence Intervals, and Sample Size

The analysis of survey items B1–B5 regarding students' environmental values and attitudes is presented in Table 10 below.

Journal of Ecohumanism
2025
Volume: 4, No: 2, pp. 320 – 339
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v4i2.6007

Table 10. Descriptive Statistics for Environmental Values and Attitudes

Measurement Variable	*N*	Pre-Test			Post-Test		
		M	*SD*	*95%CI*	*M*	*SD*	*95%CI*
Control	49	3.00	0.54	[2.85,3.16]	3.20	0.76	[2.98,3.41]
Experimental	58	3.23	0.59	[3.07,3.39]	3.50	0.57	[3.35,3.65]
Total	107	3.13	0.58	[3.02,3.24]	3.36	0.68	[3.23,3.49]

Pre-Test t-Test

As shown in Table 10, the pre-test means for the control and experimental groups are 3.00 and 3.23, respectively. To examine whether there is a significant difference between the groups at the pre-test stage, an independent samples two-tailed t-test was conducted. The results showed a t-value of 2.04 with a p-value of 0.43 ($p > 0.05$), indicating no significant difference between the pre-test scores of the control and experimental groups in terms of environmental values and attitudes.

ANCOVA Analysis

An ANCOVA was conducted to examine the relationship between groups and pre-/post-test scores. Post-test scores were used as the dependent variable, pre-test scores as the covariate, and group (control vs. experimental) as the fixed factor. The results of the ANCOVA are presented in Table 11.

Table 11. ANCOVA Summary for Post-Test Scores Across Groups

Dependent Variable Post-Test Scores	ANCOVA Summary for Post-Test Scores Across Groups				
	SS	*df*	*MS*	*F*	*p*
Group	0.55	1	0.55	1.81	0.18

The results indicate that the difference in teaching methods did not have a significant impact on post-test scores for environmental values and attitudes, as the p-value of 0.18 ($p > 0.05$) did not reach the threshold for significance.

Both the experimental group and the control group participants showed higher post-test performance in environmental concept knowledge compared to their pre-test performance after undergoing the environmental course instruction. However, the above analysis indicates that the different teaching methods between groups did not have a significant impact. Therefore, a non-parametric Wilcoxon test was conducted to determine whether the post-test scores were significantly higher than the pre-test scores for each group or not significant at all.

Wilcoxon Test on Pre-Test and Post-Test Score Improvements across Groups

Traditional Lecture-Based Teaching

Using nonparametric Wilcoxon signed-rank tests, the analysis revealed that students in the control group, who underwent traditional lecture-based teaching, showed significant differences in their pre-test and post-test scores for environmental values and attitudes. The p-value for this test was 0.02 ($p < 0.05$), indicating that the post-test scores were significantly higher than the pre-test scores for the control group.

Journal of Ecohumanism
2025
Volume: 4, No: 2, pp. 320 – 339
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v4i2.6007

Computer-Based RPG Game Teaching Module

Similarly, a nonparametric Wilcoxon signed-rank test revealed that students in the experimental group, who participated in the computer-based RPG game teaching module, also exhibited significant differences in their pre-test and post-test scores for environmental values and attitudes. The p-value for this test was 0.00 ($p < 0.05$), confirming that the post-test scores were significantly higher than the pre-test scores for the experimental group.

Although both the experimental and control groups showed significant improvements in post-test scores compared to pre-test scores, ANCOVA results indicated no significant difference between the two groups. However, based on mean score comparisons, the improvement (post-test score minus pre-test score) for the experimental group was 0.27, compared to 0.20 for the control group, suggesting that the experimental group still performed better overall.

Impact on Students' Environmental Action Skills

Descriptive Statistics

Mean, Standard Deviation, Confidence Intervals, and Sample Size

The analysis of survey items C1–C9 and C11–C12 for environmental action skills is presented in Table 12 below.

Table 12. Descriptive Statistics for Environmental Action Skills

Measurement Variable	***N***	**Pre-Test**			**Post-Test**		
		M	*SD*	*95%CI*	*M*	*SD*	*95%CI*
Control	49	3.51	0.49	[3.38,3.66]	3.71	0.78	[3.55,3.87]
Experimental	58	3.80	0.46	[3.68,3.92]	4.03	0.67	[3.90,4.17]
Total	107	3.67	0.49	[3.58,3.76]	3.89	0.53	[3.78,4.00]

Pre-Test t-Test

As shown in Table 12, the pre-test means for the control and experimental groups were 3.51 and 3.80, respectively. To examine whether there was a significant difference between the groups at the pre-test stage, an independent samples two-tailed t-test was conducted. The t-value for environmental action skills was 3.04, with a p-value of 0.00 ($p < 0.05$), indicating a significant difference between the pre-test scores of the control and experimental groups.

ANCOVA Analysis

An ANCOVA was conducted to examine the relationship between groups and pre-/post-test scores. Post-test scores were used as the dependent variable, pre-test scores as the covariate, and group (control vs. experimental) as the fixed factor. The results of the ANCOVA are presented in Table 13.

Table 13. ANCOVA Summary for Post-Test Scores Across Groups

Dependent Variable Post-Test Scores	**ANCOVA Summary for Post-Test Scores Across Groups**				
	SS	*df*	*MS*	*F*	*p*
Group	0.26	1	0.26	1.80	0.18

Journal of Ecohumanism
2025
Volume: 4, No: 2, pp. 320 – 339
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v4i2.6007

The results indicate no significant difference between the two teaching methods in terms of their impact on post-test scores for environmental action skills, as the p-value of 0.18 ($p > 0.05$) did not reach the threshold for significance.

Both the experimental group and the control group participants demonstrated higher post-test performance in environmental action skills compared to their pre-test performance after undergoing the environmental course instruction. However, the analysis indicated that the different teaching methods between the groups did not have a significant impact. Therefore, a non-parametric Wilcoxon test was conducted to determine whether the post-test scores were significantly higher than the pre-test scores for each group or whether the differences were not significant.

Wilcoxon Test on Pre-Test and Post-Test Score Improvements across Groups

Traditional Lecture-Based Teaching

Using nonparametric Wilcoxon signed-rank tests, the analysis showed that students in the control group, who received traditional lecture-based teaching, demonstrated significant improvements in environmental action skills. The p-value was 0.00 ($p < 0.05$), indicating that the post-test scores were significantly higher than the pre-test scores in this group.

Computer-Based RPG Game Teaching Module

Similarly, the nonparametric Wilcoxon signed-rank test revealed that students in the experimental group, who participated in the computer-based RPG game teaching module, also exhibited significant improvements in environmental action skills. The p-value was 0.00 ($p < 0.05$), confirming that the post-test scores were significantly higher than the pre-test scores in this group.

Although both groups showed significant improvements in post-test scores compared to pre-test scores, ANCOVA analysis indicated no significant difference between the two groups. However, comparing the mean differences (post-test minus pre-test), the experimental group showed an improvement of 0.23, compared to 0.20 for the control group, suggesting that the experimental group performed slightly better overall.

Impact on Students' Environmental Action Experience

Descriptive Statistics

Mean, Standard Deviation, Confidence Intervals, and Sample Size

The analysis of survey items F1–F10 for environmental action experience is presented in Table 14 below.

Table 14. Descriptive Statistics for Environmental Action Experience

Measurement Variable	***N***	**Pre-Test**			**Post-Test**		
		M	*SD*	*95%CI*	*M*	*SD*	*95%CI*
Control	49	3.15	0.64	[2.98,3.33]	3.16	0.62	[2.98,3.34]
Experimental	58	3.49	0.59	[3.34,3.64]	3.75	0.57	[3.60,3.90]
Total	107	3.33	0.62	[3.22,3.45]	3.48	0.66	[3.35,3.61]

Pre-Test t-Test

As shown in Table 15, the pre-test means for the control and experimental groups were 3.15 and 3.49,

Journal of Ecohumanism
2025
Volume: 4, No: 2, pp. 320 – 339
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v4i2.6007

respectively. An independent samples two-tailed t-test was conducted to examine whether there was a significant difference between the groups at the pre-test stage. The t-value for environmental action experience was 2.91, with a p-value of 0.00 ($p < 0.05$), indicating a significant difference in pre-test scores between the two groups.

ANCOVA Analysis

An ANCOVA was conducted to examine the relationship between groups and pre-/post-test scores. Post-test scores were used as the dependent variable, pre-test scores as the covariate, and group (control vs. experimental) as the fixed factor. The results of the ANCOVA are presented in Table 15.

Table 15. ANCOVA Summary for Post-Test Scores Across Groups

Dependent Variable Post-Test Scores	**ANCOVA Summary for Post-Test Scores Across Groups**				
	SS	*df*	*MS*	*F*	*p*
Group	3.15	1	3.15	16.79	0.00**

Note: $p < 0.05$

The results indicate a significant difference in post-test scores between the two teaching methods ($p = 0.00$, $p < 0.05$), demonstrating that the different teaching modules had a significant impact on the environmental action experience of the participants.

The experimental group participants demonstrated higher post-test performance in environmental action experience compared to their pre-test performance after undergoing the environmental course instruction. Based on the analysis, it was found that the different teaching methods between the groups had a significant impact, leading to the conclusion that the experimental group's post-test performance was significantly better than their pre-test performance.

Impact on Students' Interest in Environmental Course Learning

Descriptive Statistics

Mean, Standard Deviation, Confidence Intervals, and Sample Size

The analysis of survey items A7, A8, C10, and E2 regarding students' interest in environmental course learning is presented in Table 16 below.

Table 16. Descriptive Statistics for Students' Interest in Environmental Course Learning

Measurement Variable	***N***	**Pre-Test**			**Post-Test**		
		M	*SD*	*95%CI*	*M*	*SD*	*95%CI*
Control	49	3.51	0.46	[3.38,3.64]	3.43	0.58	[3.27,3.60]
Experimental	58	3.74	0.48	[3.61,3.86]	3.93	0.56	[3.78,4.07]
Total	107	3.63	0.48	[3.54,3.72]	3.70	0.62	[3.58,3.82]

Pre-Test t-Test

As shown in Table 16, the pre-test means for the control and experimental groups were 3.51 and 3.74, respectively. An independent samples two-tailed t-test was conducted to determine whether there was a significant difference in pre-test scores between the groups. The t-value for students' interest in environmental course learning was 2.49, with a p-value of 0.01 ($p < 0.05$). This indicates a significant

Journal of Ecohumanism
2025
Volume: 4, No: 2, pp. 320 – 339
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v4i2.6007

difference in pre-test scores between the control and experimental groups.

ANCOVA Analysis

An ANCOVA was conducted to examine the relationship between groups and pre-/post-test scores. Post-test scores were used as the dependent variable, pre-test scores as the covariate, and group (control vs. experimental) as the fixed factor. The results of the ANCOVA are presented in Table 17.

Table 17. ANCOVA Summary for Post-Test Scores Across Groups

Dependent Variable Post-Test Scores	**ANCOVA Summary for Post-Test Scores Across Groups**				
	SS	*df*	*MS*	*F*	*p*
Group	4.20	1	4.20	14.13	0.00**

Note: p < 0.05

The results indicate a significant difference in post-test scores between the two teaching methods ($p = 0.00$, $p < 0.05$), suggesting that the different teaching modules had a significant impact on students' interest in environmental course learning.

The experimental group participants demonstrated higher post-test performance in their interest in environmental course learning compared to their pre-test performance after undergoing the environmental course instruction. Based on the analysis, it was found that the different teaching methods between the groups had a significant impact, leading to the conclusion that the experimental group's post-test performance was significantly better than their pre-test performance.

Conclusion

Performance in Environmental Awareness and Attitude

This study utilized a self-developed environmental education course evaluation scale to examine changes in students' environmental awareness and attitudes. Students in the experimental group, taught using the computer-based RPG game teaching module, showed significant improvement in post-test scores compared to pre-test scores. Conversely, students in the control group, taught using traditional lecture-based teaching, did not demonstrate significant improvement in post-test scores. These results indicate that the computer-based RPG game teaching module is more effective than traditional lecture-based teaching in enhancing environmental awareness and attitudes.

Performance in Environmental Concept Knowledge

Using the subscale of environmental concept knowledge from the self-developed environmental education course evaluation scale, this study examined changes in students' understanding of environmental concept knowledge. Students in the experimental group showed significant improvement in post-test scores compared to pre-test scores. Although the control group also showed some improvement, it was not statistically significant. These findings suggest that the computer-based RPG game teaching module is more effective than traditional lecture-based teaching in improving environmental concept knowledge.

Performance in Environmental Values and Attitudes

This study utilized the environmental values and attitudes subscale to examine changes in students' environmental values and attitudes. The experimental group showed significant improvement in post-test scores compared to pre-test scores. Although the control group also showed notable improvement, a comparison of mean score differences revealed that the computer-based RPG game teaching module was

Journal of Ecohumanism
2025
Volume: 4, No: 2, pp. 320 – 339
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v4i2.6007

more effective than traditional lecture-based teaching in enhancing environmental values and attitudes.

Performance in Environmental Action Skills

Using the environmental action skills subscale, this study examined changes in students' environmental action skills. The experimental group demonstrated significant improvement in post-test scores compared to pre-test scores. While the control group also showed notable improvement, a comparison of mean score differences confirmed that the computer-based RPG game teaching module was more effective than traditional lecture-based teaching in fostering environmental action skills.

Performance in Environmental Action Experience

This study utilized the environmental action experience subscale to examine changes in students' environmental action experience. The experimental group showed significant improvement in post-test scores compared to pre-test scores, indicating that participants had experiences of environmental action during the teaching period. In contrast, the control group showed no significant improvement. These findings highlight the greater effectiveness of the computer-based RPG game teaching module in improving environmental action experience compared to traditional lecture-based teaching.

Performance in Interest in Environmental Courses

This study used the interest in environmental courses subscale to examine changes in students' interest in environmental courses. Students in the experimental group demonstrated significant improvement in post-test scores compared to pre-test scores, suggesting increased interest in environmental protection and related courses after the teaching intervention. In contrast, students in the control group showed no significant improvement. These results confirm that the computer-based RPG game teaching module is more effective in fostering interest in environmental courses than traditional lecture-based teaching.

Overall Conclusion

In terms of environmental awareness and attitude, environmental concept knowledge, environmental values and attitudes, environmental action skills, environmental action experience, and interest in environmental courses, the computer-based RPG game teaching module had a positive impact on students. The results indicate that this teaching method is more effective than traditional lecture-based teaching in achieving the objectives of environmental education.

References

Alisat, S., & Riemer, M. (2015). The environmental action scale: Development and psychometric evaluation. Journal of Environmental Psychology, 43, 13–23.

Becker, K. (2007). Digital game-based learning once removed: Teaching teachers. British Journal of Educational Technology, 38(3), 478–488. https://doi.org/10.1111/j.1467-8535.2007.00711.x

Bloom, B. (1969). Some Theoretical Issues Relating to Educational Evaluation. 10(10). https://doi.org/10.1177/016146816907001003

Boonstra, W. J., & Österblom, H. (2014). A chain of fools: Or, why it is so hard to stop overfishing. Maritime Studies, 13(1), 15. https://doi.org/10.1186/s40152-014-0015-4

Brooks, J. (2016). Food security and the sustainable development goals. https://www.oecd-ilibrary.org/economics/debate-the-issues-new-approaches-to-economic-challenges/food-security-and-the-sustainable-development-goals_9789264264687-27-en

Brundtland, G. H. (1987). Our common future—Call for action. Environmental Conservation, 14(4), 291–294.

Cepal, N. U. (2016). The 2030 agenda and the sustainable development goals: An opportunity for Latin America and the Caribbean. https://repositorio.cepal.org/handle/11362/40156.2

Cicchino, M. I. (2015). Using game-based learning to foster critical thinking in student discourse. Interdisciplinary Journal of Problem-Based Learning, 9(2). https://scholarworks.iu.edu/journals/index.php/ijpbl/article/view/28333

Coll, M., Libralato, S., Tudela, S., Palomera, I., & Pranovi, F. (2008). Ecosystem overfishing in the ocean. PLoS One, 3(12), e3881.

Divjak, B., & Tomić, D. (2011). The impact of game-based learning on the achievement of learning goals and motivation for learning mathematics-literature review. Journal of Information and Organizational Sciences, 35(1), 15–30.

Journal of Ecohumanism
2025
Volume: 4, No: 2, pp. 320 – 339
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v4i2.6007
Garris, R., Ahlers, R., & Driskell, J. E. (2002). Games, Motivation, and Learning: A Research and Practice Model. Simulation & Gaming, 33(4), 441–467. https://doi.org/10.1177/1046878102238607

Ghilardi-Lopes, N. P., Kremer, L. P., & Barradas, J. I. (2019). The Importance of "Ocean Literacy" in the Anthropocene and How Environmental Education Can Help in Its Promotion. In N. P. Ghilardi-Lopes & F. A. D. S. Berchez (Eds.), Coastal and Marine Environmental Education (pp. 3–17). Springer International Publishing. https://doi.org/10.1007/978-3-030-05138-9_1

Hayward, K. (1990). Responsible environmental behaviour: A test of the Hines model. https://scholars.wlu.ca/etd/588/

Hines, J. M., Hungerford, H. R., & Tomera, A. N. (1987). Analysis and Synthesis of Research on Responsible Environmental Behavior: A Meta-Analysis. The Journal of Environmental Education, 18(2), 1–8. https://doi.org/10.1080/00958964.1987.9943482

Hogle, J. G. (1996). Considering games as cognitive tools: In search of effective. https://eric.ed.gov/?id=ED425737

Hu, P. J.-H., Hui, W., Clark, T. H., & Tam, K. Y. (2007). Technology-assisted learning and learning style: A longitudinal field experiment. IEEE Transactions on Systems, Man, and Cybernetics-Part A: Systems and Humans, 37(6), 1099–1112.

Huizenga, J., Admiraal, W., Akkerman, S., & Dam, G. T. (2009). Mobile game-based learning in secondary education: Engagement, motivation and learning in a mobile city game. Journal of Computer Assisted Learning, 25(4), 332–344. https://doi.org/10.1111/j.1365-2729.2009.00316.x

Hungerford, H. R., & Volk, T. L. (1990). Changing Learner Behavior Through Environmental Education. The Journal of Environmental Education, 21(3), 8–21. https://doi.org/10.1080/00958964.1990.10753743

Ifenthaler, D., Eseryel, D., & Ge, X. (2012). Assessment for Game-Based Learning. In D. Ifenthaler, D. Eseryel, & X. Ge (Eds.), Assessment in Game-Based Learning (pp. 1–8). Springer New York. https://doi.org/10.1007/978-1-4614-3546-4_1

Jackson, J. B. C., Kirby, M. X., Berger, W. H., Bjorndal, K. A., Botsford, L. W., Bourque, B. J., Bradbury, R. H., Cooke, R., Erlandson, J., Estes, J. A., Hughes, T. P., Kidwell, S., Lange, C. B., Lenihan, H. S., Pandolfi, J. M., Peterson, C. H., Steneck, R. S., Tegner, M. J., & Warner, R. R. (2001). Historical Overfishing and the Recent Collapse of Coastal Ecosystems. Science, 293(5530), 629–637. https://doi.org/10.1126/science.1059199

Jönsson, J. H. (2019). Overfishing, social problems, and ecosocial sustainability in Senegalese fishing communities. Journal of Community Practice, 27(3–4), 213–230. https://doi.org/10.1080/10705422.2019.1660290

Joshi, A., Kale, S., Chandel, S., & Pal, D. K. (2015). Likert scale: Explored and explained. British Journal of Applied Science & Technology, 7(4), 396–403.

Kieves, N. (2004). Crisis at sea: Strengthening government regulation to save marine fisheries. Minn. L. Rev., 89, 1876.

Kirriemuir, J., & McFarlane, A. (2004). Literature review in games and learning. https://telearn.hal.science/hal-00190453/

Koenigstein, S., Hentschel, L.-H., Heel, L. C., & Drinkorn, C. (2020). A game-based education approach for sustainable ocean development. ICES Journal of Marine Science, 77(5), 1629–1638.

Koutouki, K., & Phillips, F.-K. (2016). SDG 14 on Ensuring Conservation and Sustainable Use of Oceans and Marine Resources: Contributions of International Law, Policy and Governance. Issue Brief. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4493210

Leitão, R., Maguire, M., Turner, S., Arenas, F., & Guimarães, L. (2022). Ocean literacy gamified: A systematic evaluation of the effect of game elements on students' learning experience. Environmental Education Research, 28(2), 276–294. https://doi.org/10.1080/13504622.2021.1986469

Mao, W., Cui, Y., Chiu, M. M., & Lei, H. (2022). Effects of Game-Based Learning on Students' Critical Thinking: A Meta-Analysis. Journal of Educational Computing Research, 59(8), 1682–1708. https://doi.org/10.1177/07356331211007098

Mattheiss, E. E., Kickmeier-Rust, M. D., Steiner, C. M., & Albert, D. (2009). Motivation in Game-Based Learning: It's More than'Flow'. DeLFI Workshops, 7, 77–84. https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=0700efa1800714722f487ecc7bb4eee9a1e62e54#page=77

Meadows, D., Fiddaman, T., & Shannon, D. (1989). Fish banks. Institute for Policy and Social Science Research. University of New Hampshire, Durham. https://czwiki.cz/Lexikon/Fish_Banks

Mokos, M., Realdon, G., & Zubak Čižmek, I. (2020). How to increase ocean literacy for future ocean sustainability? The influence of non-formal marine science education. Sustainability, 12(24), 10647.

Möllmann, C., & Diekmann, R. (2012). Marine ecosystem regime shifts induced by climate and overfishing: A review for the Northern Hemisphere. Advances in Ecological Research, 47, 303–347.

Murawski, S. A. (2000). Definitions of overfishing from an ecosystem perspective. ICES Journal of Marine Science, 57(3), 649–658.

Partovi, T., & Razavi, M. R. (2019). The effect of game-based learning on academic achievement motivation of elementary school students. Learning and Motivation, 68, 101592.

Plass, J. L., Homer, B. D., & Kinzer, C. K. (2015). Foundations of Game-Based Learning. Educational Psychologist, 50(4), 258–283. https://doi.org/10.1080/00461520.2015.1122533

Prensky, M. (2005). Computer games and learning: Digital game-based learning. Handbook of Computer Game Studies, 18(2005), 97–122.

Qian, M., & Clark, K. R. (2016). Game-based Learning and 21st century skills: A review of recent research. Computers in Human Behavior, 63, 50–58.

Ramsey, J., Hungerford, H. R., & Tomera, A. N. (1981). The Effects of Environmental Action and Environmental Case Study Instruction on the Overt Environmental Behavior of Eighth-Grade Students. The Journal of Environmental Education, 13(1), 24–29. https://doi.org/10.1080/00958964.1981.9943021

Journal of Ecohumanism
2025
Volume: 4, No: 2, pp. 320 – 339
ISSN: 2752-6798 (Print) | ISSN 2752-6801 (Online)
https://ecohumanism.co.uk/joe/ecohumanism
DOI: https://doi.org/10.62754/joe.v4i2.6007

Sala, E., Costello, C., Parme, J. D. B., Fiorese, M., Heal, G., Kelleher, K., Moffitt, R., Morgan, L., Plunkett, J., & Rechberger, K. D. (2016). Fish banks: An economic model to scale marine conservation. Marine Policy, 73, 154–161.

Shi, Y.-R., & Shih, J.-L. (2015). Game factors and game-based learning design model. International Journal of Computer Games Technology, 2015, 11–11.

Śnieżyński, B., & Koźlak, J. (2005). Learning in a Multi-agent Approach to a Fish Bank Game. In M. Pěchouček, P. Petta, & L. Z. Varga (Eds.), Multi-Agent Systems and Applications IV (Vol. 3690, pp. 568–571). Springer Berlin Heidelberg. https://doi.org/10.1007/11559221_62

Squire, K. (2005). Changing the game: What happens when video games enter the classroom? Innovate: Journal of Online Education, 1(6). https://www.learntechlib.org/p/107270/

Thomas, S. (2004). Simulations and the Future of Learning: An Innovative (and Perhaps Revolutionary) Approach to E-learning. On the Horizon, 12(1), 45–51.

Tobias, S., Fletcher, J. D., & Wind, A. P. (2014). Game-Based Learning. In J. M. Spector, M. D. Merrill, J. Elen, & M. J. Bishop (Eds.), Handbook of Research on Educational Communications and Technology (pp. 485–503). Springer. https://doi.org/10.1007/978-1-4614-3185-5_38

Torralba-Burrial, A., & Dopico, E. (2023). Promoting the Sustainability of Artisanal Fishing through Environmental Education with Game-Based Learning. Sustainability, 15(17), 12905.

Weines, J. (2019). Promoting 21st century skills with game-based learning in interdisciplinary fisheries education. Weines, J.(2021). Game-Based Learning for Marine Resource Management: Reflections on Using Games in the Bachelor of Science in Fisheries and Aquaculture.(Doctoral Thesis). Https://Hdl. Handle. Net/10037/21968. https://munin.uit.no/handle/10037/18528

Weines, J. (2021). Game-based learning for marine resource management: Reflections on using games in the Bachelor of Science in Fisheries and Aquaculture. https://munin.uit.no/handle/10037/21968.