

Drone-Simulated 3D Games for Wildlife Exploration and Learning: An Immersive Approach to Enhance Conservation Awareness

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ABSTRACT

The rapid decline in global biodiversity, driven by deforestation and illegal wildlife trade, demands innovative approaches to increase public awareness and encourage conservation efforts. This study presents the design, development and evaluation of BioScapeMY, a drone-simulated 3D game aimed at enhancing wildlife conservation awareness among youth. We followed a three-phase game development approach: pre-test (baseline assessment), intervention (gameplay experience), and post-test (impact evaluation). The key features of the game include interactive drone navigation, embedded educational quizzes focuses on endangered species and biodiversity threats, and a realistic 3D environment representing Malaysia's wildlife ecosystems. Results of user evaluation showed significant improvements in participants' knowledge and awareness of conservation issues, with notable increases in understanding of biodiversity threats and endangered species. Participants also found the game highly engaging and educational, consistently rating it positively in terms of usability, clarity, and enjoyment. These findings indicate that BioScapeMY is an effective and engaging educational tool for raising conservation awareness among youth. The study also emphasizes the broader potential of interactive digital games to deepen environmental understanding and inspire future conservation advocates.

Keywords: game-based learning, serious games, wildlife conservation education, drone simulation, educational game, climate change

1 INTRODUCTION

The rapid decline of global biodiversity, driven by deforestation, illegal wildlife trade, and habitat destruction, poses significant threats to ecosystems and the survival of endangered species [1]. In Malaysia, a country rich in diverse ecosystems, the loss of biodiversity is particularly alarming. Despite ongoing government initiatives, public engagement in wildlife and environment

conservation particularly among younger generations remains limited [2]. Traditional conservation education often falls short in creating a lasting impact, as it may not resonate well with today's youth. This highlights the urgent need for more engaging, accessible, and effective approaches to promote awareness and enhance participation in wildlife conservation.

In this paper, we present the design, development and evaluation of BioScapeMY, a drone-simulated 3D game that uses aerial exploration as a core mechanic to support dynamic perspective-shifting in wildlife conservation education. Drone simulation offers a novel and immersive approach to educational gaming, enabling experiences that surpass the limitations of traditional methods. By allowing players to navigate realistic 3D environments from a bird's-eye view and interact with wildlife, the game promotes a more holistic understanding of ecosystems and conservation challenges. This multiscale navigation, which allows seamless transition between broad ecosystem overviews and detailed interactions with flora and fauna, encourages systems thinking and supports contextual learning about biodiversity [3].

Besides, players will engage in exploratory and task-driven activities, which include exploring the wildlife environment, searching and identifying animal tracks, counting and collecting information about endangered species. These tasks are interwoven with narrative prompts and environmental storytelling, ensuring that gameplay remains purposeful while reinforcing educational objectives. Additionally, realistic constraints such as limited drone battery life mirror real-world challenges of drone usage in conservation work, embedding authenticity within the gameplay experience [4].

Grounded in experiential learning theory which emphasizes learning through reflection on doing, *BioScapeMY*, will integrate post-experience reflective tasks. For example, embedded quizzes triggered contextually during gameplay will provide immediate feedback and reinforce content retention. Annotated wildlife journals will not only measure knowledge acquisition but also promote critical thinking and ethical reasoning related to conservation dilemmas. Player responses are evaluated through both quantitative pre-test and post-test assessments to measure the effectiveness of the games at encouraging wildlife conservation awareness [5].

Accordingly, the objectives of this study are to assess the effectiveness of BioScapeMY in enhancing understanding of Malaysia's wildlife and biodiversity among youth, as well as to evaluate how the game impacts their motivation to engage in conservation activities. Additionally, the study also explores the functionality and user experience of the game to identify its strengths and areas for improvement. Through this evaluation, we aim to contribute to the growing body of knowledge on the use of interactive digital tools for environmental conservation education.

The remainder of this paper is organized as follows: Section 2 reviews relevant case studies, with an emphasis on interactive features within game-based learning environments for conservation and environmental education. Section 3 describes the design, development, and evaluation of BioScapeMY, including its features, gameplay mechanics, and user evaluation methods. Section 4 presents the findings and discussion of the user evaluation, offering a detailed analysis of pre- and post-test results, user feedback, and game functionality. Finally, Section 5 concludes by summarizing the study's key findings, acknowledging its limitations, and offering recommendations for future research.

2 LITERATURE REVIEW

2.1 3D Games for Wildlife Conservation

In order to design our drone-simulated 3D Games, *BioScapeMY* – aimed at cultivating conservation awareness among Malaysian youth, we believe it is essential to ground the development process in a thorough understanding of existing educational and conservation-themed digital tools. Literature on current game-based learning environments and interactive educational content provides a foundation for identifying best practices, interactive features and design limitations. In this review we examined four closely relevant examples; (1) Planet Zoo, (2) Endling: Extinction is Forever, (3) Virtual Reality Animation of JavanRhino, and (4) IPANDA to highlight how current digital experiences foster environmental awareness and where *BioScapeMY* may innovate or improve.

2.1.1 Case Study 1 - Planet Zoo by Frontier Developments

Planet Zoo is a zoo management simulation game that merges entertainment with environmental education. Players are tasked with building and maintaining habitats, managing staff and resources, and ensuring the welfare of animals, some of which are endangered species. This gamified approach allows users to engage in indirect learning by simulating conservation practices such as breeding programs, habitat design, and sustainability-focused zoo operations [6].



Figure 1 : The splash screen of Planet Zoo.



Figure 2 : The wall for the animal ground.

Planet Zoo excels in its simulation depth and its use of systems thinking to model real-world interdependencies between animals, habitats, and human interaction. The game requires players to manage complex ecosystems within a zoo setting, balancing animal welfare, environmental conditions, and visitor education (Figure 1-4).



Figure 3 : The character (animal) of Planet Zoo.

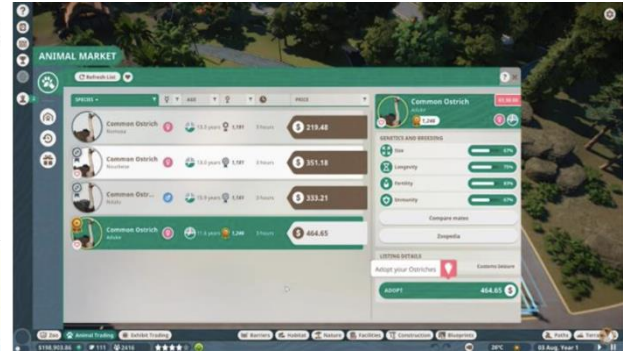


Figure 4 : The animal market in Planet Zoo.

The incorporation of conservation themes, such as species protection and ecological sustainability, aligns well with experiential learning theories, allowing players to learn through trial and error in a simulated space. Additionally, the game employs high-fidelity visuals and data-driven behaviors, which increase player immersion and believability—important elements for impactful educational experiences.

However, the game's setting within artificial zoo environments limits its ecological scope. While it mimics elements of conservation, it excludes many of the challenges faced in real-world field conservation such as habitat fragmentation, poaching, and climate change. These omissions risk oversimplifying the realities of wildlife protection. Moreover, the lack of explicit educational content such as guided reflection, narrative framing, or in-game assessments means that much of the learning is incidental rather than intentional [7]. As a result, players may enjoy the game without deeply internalizing its conservation messages.

2.1.2 Case Study 2 - *Endling: Extinction is Forever* by Herobeat Studios

Endling adopts a more narrative-driven approach, placing players in the role of the last surviving mother fox in a post-apocalyptic world. The game emphasizes emotional storytelling and decision-making as players struggle to protect and feed their cubs in a hostile environment shaped by human exploitation and ecological collapse [8].

Endling offers a unique emotional lens to explore conservation. Unlike traditional education games, it leans heavily on affective engagement, drawing players into the personal struggle of a mother fox surviving in a world shaped by ecological collapse (see Figure 5). This narrative approach has been shown to increase empathy, ethical reflection, and motivation to act, which are key affective outcomes associated with transformative learning [9]. The environmental storytelling is subtle yet powerful, using gameplay mechanics (e.g., scarcity of food, threats from humans) to mirror real-world ecological pressures.

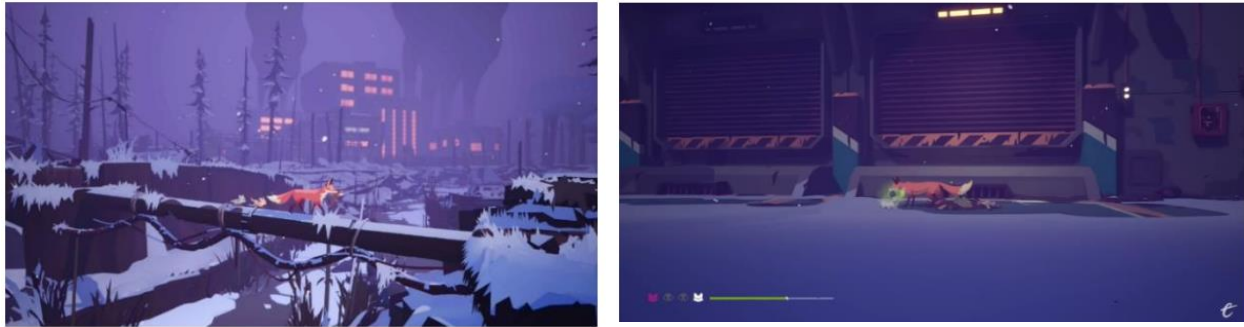


Figure 5: The consequences of environmental destruction, forcing the last mother fox to scavenge for scraps (left); and Mommy Fox looking for food to survive (right).

However, while *Endling* is emotionally resonant, its educational content lacks depth and breadth. It does not explicitly teach scientific principles related to ecosystems, species interdependence, or conservation policy. Its linear gameplay structure also limits replayability and learner autonomy. Additionally, because the game's core goal is to create an emotional impact, its mechanics are designed more for storytelling than for exploration or experimentation, thereby limiting its capacity to support constructivist or inquiry-based learning models. Thus, while *Endling* succeeds in raising awareness, it does not equip players with the scientific knowledge or practical strategies needed to understand or solve environmental problems.

2.1.3 Case Study 3 - Virtual Reality Animation of Javan Rhino

The Javan Rhino Virtual Reality (VR) application is an innovative digital conservation tool developed specifically for the Indonesian context to raise awareness about the critically endangered Javan rhinoceros [10]. As one of the rarest large mammals on Earth with its last remaining population confined to Ujung Kulon National Park in Indonesia, this species faces significant conservation challenges due to habitat loss and human encroachment. The VR application serves as an educational platform, allowing users particularly Indonesian students, conservationists, and the general public, to experience the Javan rhino's natural habitat and understand the threats it faces without physically visiting the protected area (Figure 6). This is especially crucial given that Ujung Kulon is a restricted-access conservation zone, limiting direct public engagement with the species.

One of the key strengths of the Javan Rhino VR application is its localized focus on Indonesian wildlife conservation. The application provides a realistic 3D simulation of Ujung Kulon's dense rainforest ecosystem, complete with environmental sounds and interactive learning modules that educate users on the rhino's diet, behavior, and conservation efforts led by Indonesian authorities. This immersive approach enhances public engagement and fosters a stronger sense of national responsibility toward conservation.



Figure 6: Examples of 3D VR animation of Javan Rhino.

However, despite its strengths, the application has several notable limitations. The 3D models and textures of the rhino and its environment are not highly detailed, reducing the realism and immersion of the experience. Additionally, the interactive elements remain relatively basic, limiting user engagement beyond passive observation. Unlike more advanced conservation VR experiences, this application lacks gamification elements, such as quizzes, missions, or real-time ecological challenges, which could make learning more engaging for younger audiences. Another significant limitation is accessibility, as the application requires VR-compatible hardware, which is still relatively expensive and not widely available in many parts of Indonesia.

2.1.4 Case Study 4 –IPANDA: A Playful Hybrid Product

IPANDA is a hybrid educational product that combines digital gameplay with hands-on activities to teach children about wildlife conservation. It integrates tangible play elements with interactive storytelling and game-based challenges, creating an engaging and immersive learning experience. By blending physical and digital components, IPANDA encourages active participation, making conservation education more dynamic and interactive [11].

One of IPANDA's strengths is its ability to enhance experiential learning by combining real-world interactions with digital engagement. The hands-on activities provide a tangible connection to conservation themes, while the digital game introduces key concepts through interactive storytelling and decision-making scenarios. This blended approach fosters curiosity and deeper understanding, making learning both enjoyable and educational (Figure 7).



Figure 7: Prototype of IPANDA comprising of a tangible artificial pet and a 2D game (left); and a child interact with IPANDA (right).

However, IPANDA has limitations, particularly in its digital game component. The literature lacks details on gamification strategies, such as rewards or progression systems, and does not define specific game mechanics like resource management or strategic decision-making. Additionally, its connection to broader conservation goals, such as biodiversity protection, is not well elaborated. Without structured learning objectives, there is a risk that entertainment may overshadow educational value, and the product's focus on younger children may limit its appeal for older learners.

Overall, IPANDA presents a promising approach to conservation education by integrating hands-on play with digital engagement. While it has strong potential to increase conservation awareness among children, the lack of clarity regarding game mechanics, engagement strategies, and educational structure raises concerns about its effectiveness. Further research and refinement are needed to ensure the digital component effectively reinforces conservation principles and learning objectives.

2.2 Comparative Insights and Implications for *BioscapeMY*

Across the reviewed examples, several key design principles emerge: immersive realism, emotional engagement, and structured knowledge scaffolding. While each offers unique pedagogical strengths, none fully captures the synergy between experiential learning, ecological authenticity, and contextual relevance to Malaysian biodiversity. *BioScapeMY* is positioned to address this opportunity by integrating best practices from these precedents into a localized, immersive educational experience.

Firstly, *BioScapeMY* aims to provide an open-world drone simulation experience that is grounded in Malaysia's unique ecological landscapes. Unlike *Planet Zoo*, which is confined to zoo environments, this project seeks to simulate actual Malaysian biomes, such as tropical rainforests, wetlands, and mangroves, thereby enabling players to engage with real-world habitats. This approach not only enhances ecological literacy but also fosters a sense of place-based stewardship among players, which is particularly critical when targeting younger audiences who may have limited direct exposure to these environments.

Besides, the game intends to blend task-oriented gameplay with narrative-driven storytelling, thereby fostering both emotional and cognitive engagement. This dual strategy draws inspiration from *Endling*, which demonstrates the emotional power of narrative to convey environmental urgency. However, *BioScapeMY* advances this by incorporating structured learning objectives and interactive decision-making, ensuring that emotional resonance is accompanied by meaningful educational takeaways. By situating the player in scenarios that simulate real conservation dilemmas, the game encourages ethical reflection, problem-solving, and empathy—all key components in promoting long-term conservation values.

While both the Javan Rhino VR application and *BioScapeMY* focus on wildlife conservation education through immersive digital experiences, they differ significantly in scope, design, and interactivity. The Javan Rhino VR is a static, educational simulation primarily designed for raising awareness about a single endangered species in a specific Indonesian habitat. In contrast, *BioScapeMY* is a more dynamic, interactive 3D game that integrates drone-simulated exploration to provide a broader, multi-species conservation experience.

Additionally, while the Javan Rhino VR application is a valuable step toward digital conservation awareness in Indonesia, its limitations in interactivity, accessibility, and gamification restrict its overall impact. In contrast, *BioScapeMY* offers a more versatile and interactive approach, making it a stronger tool for wildlife education and engagement at a larger scale. With better interactivity, accessibility, and game-based learning mechanics, we believe *BioScapeMY* could significantly improve the effectiveness of Malaysia conservation education efforts.

Meanwhile, IPANDA and *BioScapeMY* are both designed to enhance conservation awareness but differ in their approach and technology. IPANDA is a hybrid product that combines both physical play with digital tool (2D game), primarily targeting young children about panda conservation. However, its game mechanics and engagement strategies are not well-documented. In contrast, *BioScapeMY* is a drone-simulated 3D game that offers a fully digital, immersive wildlife exploration experience, catering to students, educators, and conservation enthusiasts. Besides, while IPANDA focuses on species-specific learning i.e. Panda, *BioScapeMY* provides a broader biodiversity education through virtual drone navigation.

Taken together, these design choices position *BioScapeMY* as a hybrid educational platform that synthesizes immersion, interactivity, and environmental curriculum. By addressing the limitations observed in existing systems and contextualizing the gameplay within Malaysia's conservation challenges, the project aspires to serve as both a compelling digital experience and an impactful educational tool.

Table 1 provides a comparative overview of three existing educational platforms on wildlife conservation i.e. *Planet Zoo*, *Endling: Extinction is Forever*, Javan Rhino VR, IPANDA, alongside our proposed design for *BioScapeMY*. The table synthesizes each platform's educational orientation, interactivity, learning design, and engagement strategies, while highlighting their respective strengths and limitations.

Table 1: Comparison of Game-based Learning Applications for Wildlife Conservation.

Feature / Criteria	Planet Zoo	Endling: Extinction	IPANDA	Javan Rhino VR	BioScapeMY
Primary Format	3D simulation of Zoo Management	Narrative-driven 3D side-scroller	Hybrid: Tangible toy + 2D digital game	Virtual Reality (VR) simulation	3D drone-simulated exploration game
Core Learning Approach	Systems thinking through zoo management	Affective engagement via storytelling	Experiential learning (physical-digital integration)	Immersive VR observation of a single species	Experiential learning via simulation, storytelling & interactive assessments
Target Age Group	Teens & adults (management complexity)	Teens & adults (mature themes)	Children (physical-digital play)	Students & conservationists (VR learning)	Students, educators, conservationists
Educational Strengths	Deep ecological simulation Conservation-focused	Emotional impact Ethical & empathy-driven learning	Hands-on tangible artificial pet + digital engagement Encourages curiosity & interactive play	Species-specific awareness (Javan Rhino) Immersive rainforest experience	Real-world ecological settings (Malaysia-specific) Combines narrative, interactivity, and curriculum
	Realistic animal behavior	Narrative reinforces conservation urgency		Localized Indonesian conservation themes	Multiscale perspective switching (drone POV)
				Basic interactivity	Still in development (requires usability/impact testing)
Weaknesses	Zoo-based conservation is artificial – Lacks structured learning objectives	Lacks scientific depth Limited interactivity	Gamification mechanics unclear Conservation themes not well-defined	Limited gamification Requires expensive VR hardware	
User Interaction	High (construction resource management, feedback loops) Implicit via management systems	Moderate (linear narrative, decision points) Explicit via narrative-driven survival story	High (physical-digital interaction)	Low (mostly observation-based)	High (exploration, task completion, in-game reflection)
Conservation Themes		Minimal (narrative feedback only)	Unclear (depends on physical-digital integration)	Explicit via visual storytelling & species focus	Deeply embedded: habitat health, species tracking, ethical choices
Assessment /Feedback Mechanisms	Minimal (no structured assessments)			None (observation-based)	Strong (in-game quizzes, scenario-based reflection, data logs)
Immersive Quality	High (realistic animal AI, ecosystems)	Moderate to High (emotional engagement)	Moderate (physical-digital hybrid)	Moderate (VR setting, but limited interactivity)	High (real-world mapping, ambient storytelling, drone immersion)

This comparative analysis helps us to identify best practices in conservation-themed digital learning experiences; and position *BioScapeMY* as an innovative approach that integrates immersive simulation, emotional engagement, and curriculum-aligned content. It shows that *BioScapeMY* stands out by integrating the best practices from existing conservation education platforms while addressing their limitations.

3 METHODOLOGY

This study involves the design, development and evaluation of *BioScapeMY*, an interactive educational game aimed at fostering environmental awareness and conservation values among Malaysian youth. To effectively realize this objective, this section outlines the methodological framework adopted throughout the project. The approach encompasses multiple interrelated components, including game development processes, narrative design, character creation, and the use of visual storytelling through storyboarding. Each of these elements contributes to constructing a meaningful and engaging gameplay experience, designed not only to entertain but also to educate players on the significance of preserving Malaysia's rich biodiversity and protecting its endangered species. By integrating creative and technical strategies, the methodology aims to produce an immersive learning environment aligned with both educational goals and conservation ethics.

3.1 Preliminary Study

A preliminary user study was conducted to explore user engagement, interest, and preferences regarding wildlife conservation and the potential use of 3D drone simulators as an educational tool. The study aimed to gather initial insights into how individuals interact with wildlife conservation content, their willingness to adopt immersive learning technologies, and the features they find most valuable in such applications. By analyzing participant responses, this research seeks to identify key trends that can inform the development of our drone-simulated 3D games, ensuring they effectively engage users and enhance their wildlife conservation awareness.

The survey was distributed online through *WhatsApp* and *Telegram* groups, targeting individuals with potential interest in wildlife conservation and educational technology. A convenience sampling method was used, where participants were selected based on accessibility and willingness to respond. This approach allowed for quick and efficient data collection within a relevant audience. A total of 33 responses were collected, which is sufficient for a preliminary study as small sample sizes are commonly used in exploratory research to identify trends and refine methodologies before conducting larger studies [12]. The following Table 2 presents the result of our preliminary user study.

Table 2 : Summary result of preliminary user study.

Item	Category	N	Percentages, %
Age Group	Below 20 years old	3	9.1
	21– 30 years old	19	57.6
	31– 40 years old	6	18.2
	Over 40 years old	5	15.2
Frequency engaging with content related to wildlife conservation.	Once per day	9	27.3
	Once per week	9	27.3
	Once per month	4	12.1
	Rarely	9	27.3
	Never	2	6
I am very interested in wildlife conservation and environmental issues.	Strongly Agree	16	48.5
	Agree	15	45.5
	Neutral	1	3
	Disagree	1	3
	Strongly Disagree	0	0
I am interested to use drone-simulated 3D Games to learn more about wildlife conservation	Strongly Agree	10	30.3
	Agree	16	48.5
	Neutral	6	18.2
	Disagree	1	3
	Strongly Disagree	0	0
I would recommend others to learn about wildlife conservation through drone-simulated 3D Games	Strongly Agree	10	30.3
	Agree	14	42.4
	Neutral	6	18.2
	Disagree	3	9.1
	Strongly Disagree	0	0
Most important features for drone-simulated 3D Games	Realistic 3D environment	11	33.3
	Interactive wildlife exploration	7	21.2
	Comprehensive species information	9	27.3
	Gamified challenges and quizzes	6	18.2

Based on the above Table 2, the age distribution of our respondents showed that the majority (57.6%) were between 21–30 years old, followed by 31–40 years old (18.2%), and over 40 years old (15.2%). A small proportion of participants (9.1%) were below 20 years old. This indicates that the study primarily captured the perspectives of young adults, who are often more engaged with digital technologies and conservation-related content. Regarding engagement with wildlife conservation content, 27.3% of respondents interact with such content daily, while an equal proportion (27.3%) engage weekly. However, 27.3% rarely consume conservation-related content, and 6% never do so. This suggests a varied level of interest and awareness among the participants, with some already engaged in conservation efforts while others have limited exposure.

The respondents generally expressed high interest in wildlife conservation and environmental issues, with 48.5% strongly agreeing and 45.5% agreeing that they care about these topics. Only 3% remained neutral, while another 3% disagreed. These findings highlight a strong inclination towards environmental awareness among the participants, which is crucial for the effectiveness of

conservation-related educational tools. When asked about using a 3D drone simulator for learning about wildlife conservation, 30.3% strongly agreed, while 48.5% agreed, showing an overall positive response. A smaller percentage (18.2% remained neutral) and 3% disagreed, indicating that while the majority are open to the idea, some participants may need more exposure or incentives to engage with this technology.

A similar trend was observed when participants were asked if they would recommend the use of a 3D drone simulator for learning about conservation. 30.3% strongly agreed, 42.4% agreed, while 18.2% remained neutral, and 9.1% disagreed. This suggests that while most respondents see potential value in such an approach, some may have reservations, possibly due to unfamiliarity with the technology or concerns about its effectiveness. Regarding the most important features in 3D wildlife conservation games, respondents valued realistic 3D environments the most (33.3%), followed by comprehensive species information (27.3%). Interactive wildlife exploration (21.2%) and gamified challenges (18.2%) were also considered important. These results emphasize that users prioritize immersive and informative experiences, though elements of interactivity and gamification still play a significant role in engagement.

The findings from this preliminary study provide us valuable insights that can directly inform the design of our 3D drone-simulated wildlife conservation game. The high level of interest in wildlife conservation (with a total cumulative of 94% of respondents agreeing or strongly agreeing) suggests that users are motivated to engage with educational tools in this domain. Additionally, a cumulative of 78.8% of participants expressed interest in using a 3D drone simulator, indicating strong potential for an immersive, technology-driven learning approach. The frequency of engagement with wildlife content also highlights the need for a game that accommodates both regular and casual users, ensuring accessibility and sustained interest. Furthermore, the preference for realistic 3D environments (33.3%) and comprehensive species information (27.3%) suggests that the game should prioritize high-quality visuals and accurate ecological data to enhance the learning experience. Finally, the positive inclination towards recommending the simulator to others (a cumulative of 72.7% agreement) demonstrates its potential for wider adoption. These findings help us to refine our drone-simulated 3D game mechanics, interactivity, and educational content to maximize engagement and conservation awareness.

3.2 Games Development

The development of *BioScapeMY* adhered to a standard game development pipeline, comprising three critical phases: Pre-Production, Production, and Post-Production.

3.2.1 Pre-production : Building the Biosphere

The pre-production phase of this project focused on establishing a clear vision for the game, defining its educational and conservation objectives, and outlining the gameplay mechanics that would effectively engage players in wildlife tracking and conservation efforts. This phase also considered the challenges of integrating learning outcomes with an immersive and interactive gaming experience.

i) Concept Development

Our proposed game, *BioScapeMY*, is designed as an immersive, drone-simulated 3D experience where players assume the role of wildlife conservationists. Using virtual drone technology, players can explore dynamic, real-world-inspired ecosystems, track endangered species, and participate in conservation missions aimed at protecting wildlife and their habitats. The core objectives of the game are to raise awareness about endangered species and conservation challenges, gamify wildlife tracking through engaging and interactive gameplay, inspire interest in real-world conservation efforts, and provide an educational tool that integrates gamification with environmental learning.

Targeted at the younger generation, *BioScapeMY* particularly caters for students, general gamers, and conservation enthusiasts. For students aged 13 and above, the game serves as an interactive learning tool that can be incorporated into educational curriculums. The general public, especially individuals passionate about environmental awareness and exploration-based gaming, will find it both engaging and informative. Additionally, conservation researchers and wildlife enthusiasts can use the game as an innovative visualization tool for animal tracking data and conservation efforts.

To make conservation education more engaging, *BioScapeMY* incorporates gamification elements such as missions, challenges, and a structured progression system. Players will be able to identify different species, learn about threats such as poaching and deforestation, and simulate real-world conservation challenges. Gamification techniques such as reward points, varying levels of challenges, and unlockable game upgrades will encourage players to progress, remain engaged, and develop a deeper understanding of wildlife conservation efforts.

ii) The Characters and Story Plot Development

In the development of *BioScapeMY*, character design plays a crucial role in shaping player engagement and immersion. The game introduces three primary characters, Johan, Ben, and Maya – each bringing unique expertise that enriches the game's educational and narrative depth. Their backgrounds and skillsets not only serve to guide players but also reinforce the scientific and technological foundations of the gameplay experience.

Johan, a passionate Zoologist, serves as the game's wildlife expert, providing players with insights into animal behavior and ecosystems. His role enhances the educational depth of the game by offering scientifically accurate information on the biodiversity encountered throughout the journey. Ben, a Tech Whiz, is responsible for the game's technological advancements, particularly the AI-powered drone Anya. As a specialist in AI and programming, Ben ensures the smooth operation of the research expedition while also introducing problem-solving challenges related to drone navigation and data collection. His character highlights the increasing role of technology in modern conservation efforts. Complementing the team is Maya, a veterinarian, who provides expertise on animal health and welfare. Through her role, players learn about the challenges of wildlife rehabilitation, disease prevention, and conservation medicine. Together, these three characters create an interdisciplinary approach to conservation, reinforcing the game's educational objectives. Their interactions with Anya, the AI drone, enhance gameplay by combining real-world scientific principles with immersive storytelling. By engaging with these diverse characters, players gain a holistic understanding of

conservation, technology, and wildlife research, making *BioScapeMy* both an informative and interactive experience.

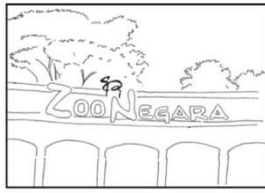
The following Table 3 presents the story plot of our drone-simulated 3D games.

Table 3: The story plot of *BioScapeMY*.

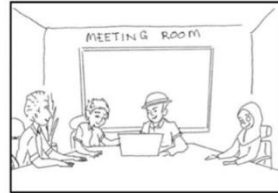
Title	Description
Act 1: Unveiling the Unknown	The research team arrives at a protected forest reserve in Pahang, Malaysia, but faces unexpected obstacles due to a natural calamity. Despite the setback, they deploy Anya, their AI-powered drone, to begin exploration.
Act 2: A World of Wonders	Players, through Anya's aerial perspective, explore breathtaking landscapes filled with diverse wildlife. Data collection begins as the team documents species, studies ecosystems, and observes animal behavior.
Act 3: Navigating the Challenge	The team encounters challenges such as limited drone battery life and dense terrain. Players must strategically plan their flight paths to maximize research efficiency while avoiding environmental hazards.
Act 4: A Hidden Paradise Unveiled	Anya discovers an uncharted valley teeming with rare and endangered species. The significance of this hidden ecosystem adds urgency to the conservation mission.
Act 5: A Critical Decision	Players must make a strategic choice: (1) continue data collection, risking Anya's loss, or (2) return to base with limited information to ensure future exploration. The decision impacts the game's outcome.
Act 6: A Sustainable Future	The team compiles research findings and collaborates with conservation organizations to protect the newly discovered ecosystem. The mission emphasizes long-term sustainability and ongoing monitoring efforts.

iii) The Storyboard

The following Figure 8 presents the detailed storyboard of *BioScapeMY*.



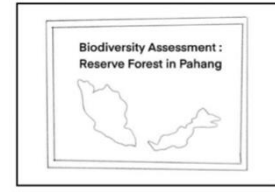
The bustling National Zoo enclosure



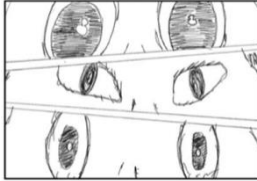
Johan, Ben and Maya listening intently to their boss.



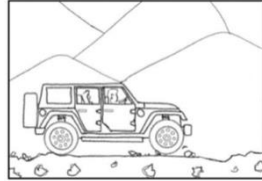
The boss point on a map highlighting a research site in Pahang



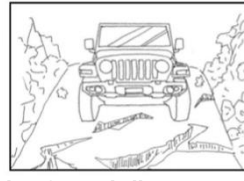
Next, their boss presents a project at Pahang Forest Reserve



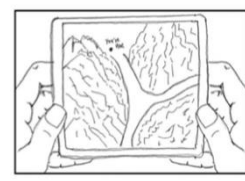
Johan, Ben & Maya exchange glances eager to embark in this journey



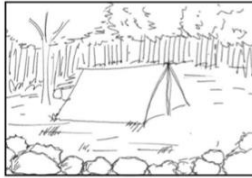
A full-loaded Jeep struggles on a muddy road, with a lush green forest in the background



They face a challenge to reach their basecamp due to broken road.



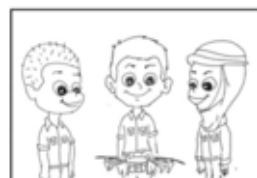
Johan, Ben and Maya huddle around a map, frustration etched on their faces. Anya lifts off from a makeshift



While the time is running, they setup their research base camp and unpacked their research equipment.



Ben proudly unveils Anya, a sleek metallic drone with advanced camera and sensors.



Johan and Maya were very excited as Ben's start to fly Anya.



landing pad and rising above the rainforest canopy.



They view Anya's camera and enjoy the breath-taking panorama of trees, and mountains.



As Anya's fly deeper into the forest, they zoom the drone's camera into a majestic rafflesia lying on the ground



Anya also captures a playful orang utan swinging through the branches.



Every flora and fauna captured by Anya's camera was recorded by Maya in her journal.



Anya descends into the cave revealing a lush untouch ecosystem teeming with life.



Suddenly, a notification appears on the screen. Anya's battery level is critically low!



Ben fly Anya back to the camp. The expedition will continue when the battery is fully charge again.



After the expedition end, Johan, Ben & Maya meet with their boss and presented their findings.

Figure 8: The Storyboard

3.2.2 Production: Bringing the Biosphere to Life

The production stage is the most vital part of the development process, where ideas and designs transition into a functional and interactive product. This stage involves several processes, including creating 2D visuals, 3D assets, building interactive scenes and integrating all components into the game engine.

i) Digitizing 2D and 3D Art

Digitizing artwork plays a critical role in creating visual aspects in the project. In digitizing art, Adobe Illustrator is one of the most prominent tools to create the project illustrations. The creation of the logo, characters, buttons, icons and background are digitized through this software tool. This software allowed for flexibility in creating scalable vector graphics, ensuring the quality of visuals remains high for every element.

In this project, there is a mixture between 2D and 3D assets to make the game feel more immersive. The storyboard and the characters in the early part of the game are made in 2D. The user interface of the game also implementing the same style of graphics. To have some motion of storyboards and characters, another software has been used to produce such animations. The implementation of 2D assets is prepared using Adobe Illustrator. These characters are made from a sketch before digitized to several layers of illustrations. Besides, the developers had designed the characters aligned with children's mind and added a little localized feature to them. The following Figure 9 shows screenshots of character design and user interface design in Adobe Illustrator.

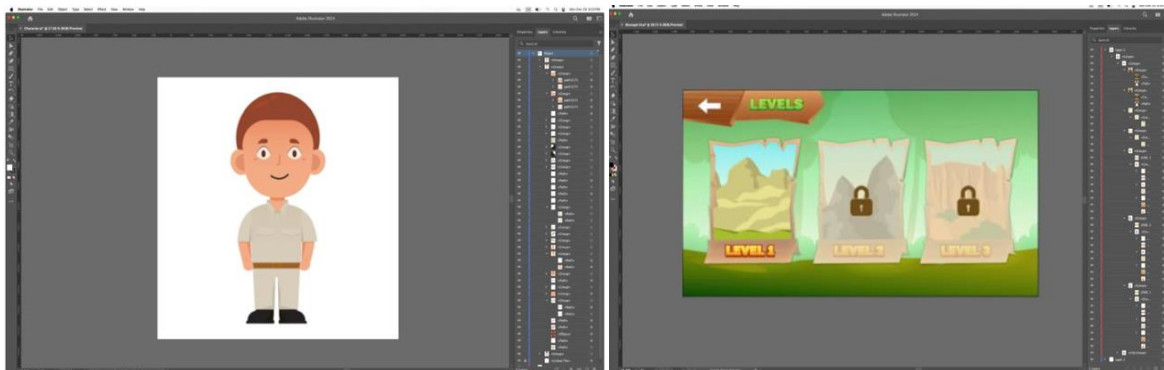


Figure 9: The illustration of Ben (left); and the user interface design in Adobe Illustrator (right).

For 3D elements, Blender was utilized to craft lifelike models of characters, terrains, and the surrounding environment. This process involved attention to detail, including texturing, lighting, and rendering, to ensure visual harmony between 2D and 3D assets. These models were further optimized for integration into the game engine to maintain smooth gameplay performance. These assets are made from scratch. The following Figure 10 shows a 3D model of the Sumatra Rhino design in Blender:

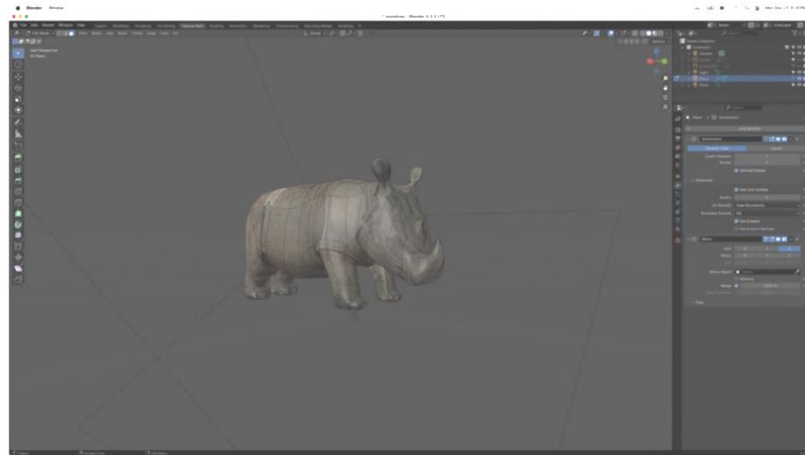


Figure 10: The 3D model of Sumatra Rhino created in Blender.

ii) Digitizing Scenes

For the next process in developing the scenes in this game, it divided into two parts, which are digitizing 2D scenes and 3D scenes. For 2D scenes, it only involves at the splash screen and story mode at the early part of the game. For digitizing 2D assets, Adobe After Effects had been utilized for this. The developers follow the sequence of the scenes exactly like in the storyboard. For this project, only keying method be implemented to produce the outcome as planned. The movement of assets being control by the key in the After Effects' software. The story mode only requires small motion effects; thus, the keying method is the best way to work it out. The following Figure 11 shows the keying process in Adobe After Effects:

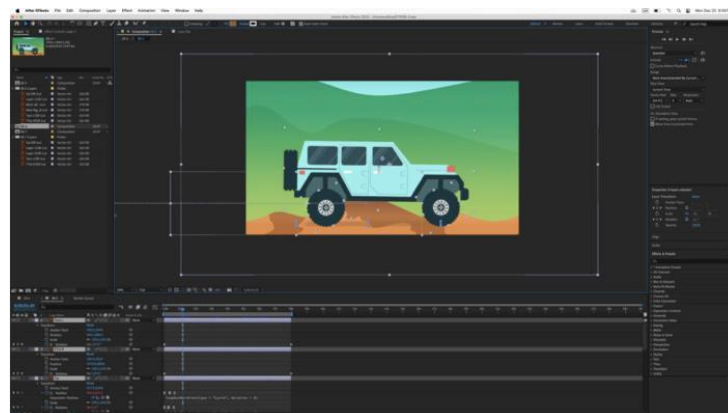


Figure 11: The keying process in Adobe After Effects.

For 3D model, there is no digitizing process from sketching to the digital format of art because the process will go straight to modelling in Blender. The scenes later are being controlled in the Unreal Engine (Figure 12).

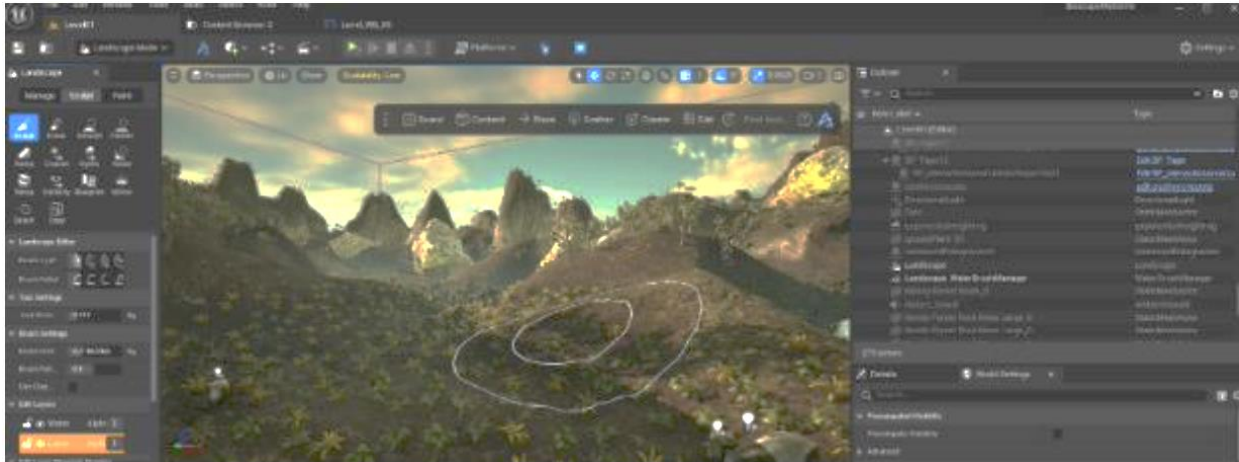


Figure 12: The landscape remodel in Unreal Engine.

The base shape of the landscape for each level is formed by using the landscaping tools in the landscape mode. To create a natural-looking landscape and environment, the form of the landscape must be organic and based on the real world. By referring to real rainforest environments, we created a landscape with limestone hills and a river.

Besides, we also use *Dash*, a plugin by *Polygonflow* made for 3D world-building. One of its popular tools which is the scatter tool helped us to create a natural-looking environment in *BioScapeMY* by scattering and randomizing plants' static mesh generation in the level. The following Figure 13 shows the rocks, decorated with scattered plants' static meshes by using the *Dash* plugin. The large rocks are blueprints created with collisions to vary the surface of the landscape.



Figure 13: The rock blueprints in *BioScapeMY*.

Besides, in order to create a realistic river, an instance called *WaterBodyRiver* in the *Water and Water Extras* plugin. These plugins are built-in plugins in Unreal Engine 5 (UE5) to ease developers in creating realistic looking bodies of water such as rivers, lakes, and oceans (Figure 14).



Figure 14: The WaterBody instance in UE5.

The interactable objects in all the levels are actors created with blueprints. The models of the actors are designed initially in Blender 3D and imported into the UE5 project file. The trace and interact mechanics are added in UE5 (Figure 15). These actors provide unlockable information widgets for players in the form of digital journals.



Figure 15: The interactable actors designed in Blender 3D.

The blueprints of the interactable actors are modified to make the actors emit sounds, lights and provide information when interacting to make the game more immersive (Figure 16).

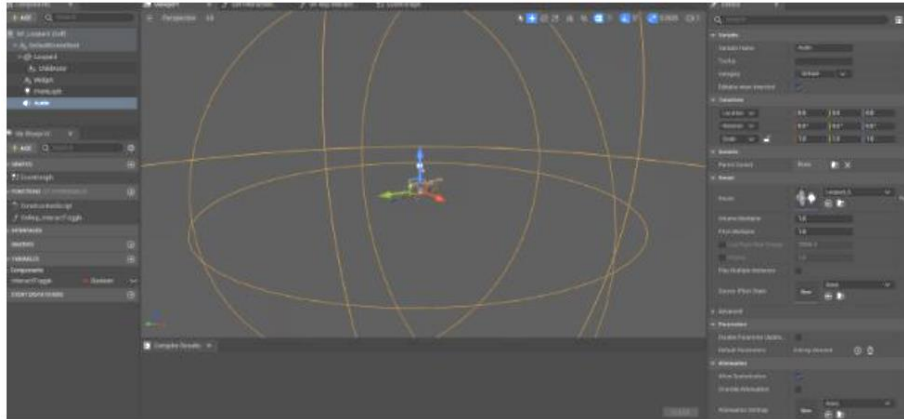


Figure 16: The interactable actor's blueprint.

iii) Recording and Digitizing Audio

To create an immersive experience in the game, we used sound effects using tools from our environment such as carabiner to produce a 'pop' sound. Developers also use some free sound effects for the animal's sound. The sound effects are tailored to the overall vibes of the game that are related to nature. For the voice-over, the developers used AI technology to do the narration in the story mode before the game started. *Elevenlabs* had been used in this project as the main source of narration tools.

iv) Authoring

The authoring phase involved integrating all the designed and digitized assets into Unreal Engine 5, where the game mechanics and interactivity were developed. This phase focused on programming interactive features, such as clickable buttons, menus, and transitions between scenes, defining the mechanics for drone exploration, quizzes, and point collection systems and implementing animations for character movements, environmental interactions, and cinematic sequences.

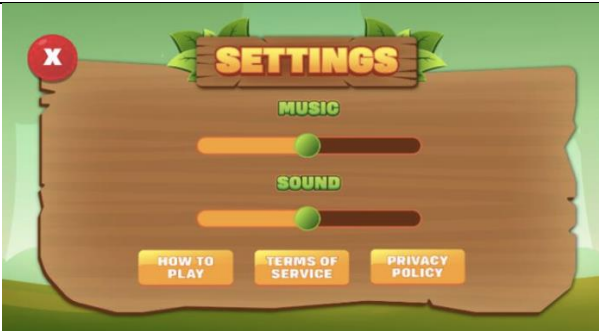
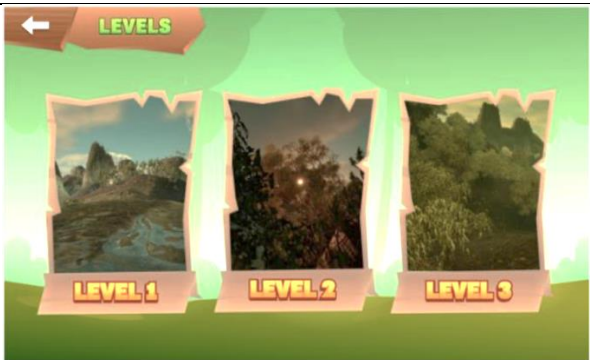
3.3 Post-production: User Evaluation

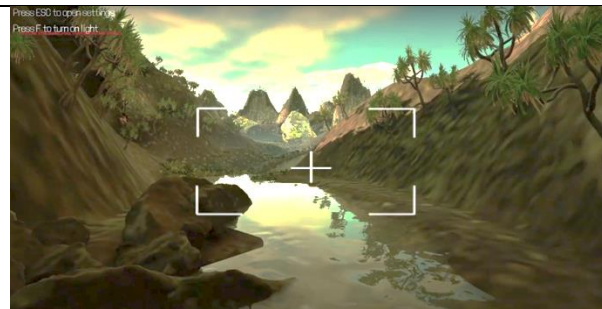
3.3.1 *BioScopeMY: The Drone-Simulated 3D Games for Wildlife Conservation Awareness*

BioScopeMY is an innovative drone-simulated 3D game designed to inspire and educate Malaysian youth on the vital importance of wildlife conservation. By immersing players in a dynamic and interactive virtual environment, the game deepens their understanding of Malaysia's diverse ecosystems and endangered species while fostering a sense of responsibility toward conservation. Through drone exploration, players actively engage with the virtual landscape, gaining valuable insights into the impact of human activities on biodiversity. With its seamless integration of educational elements and immersive gameplay, *BioScopeMY* serves as a powerful tool for shaping the next generation of Malaysian conservationists, equipping them with the knowledge and awareness

needed to safeguard the nation's rich biodiversity. The following Table 4 presents the main features in *BioScapeMY*.

Table 4: The main features in BioScapeMY and detailed descriptions.

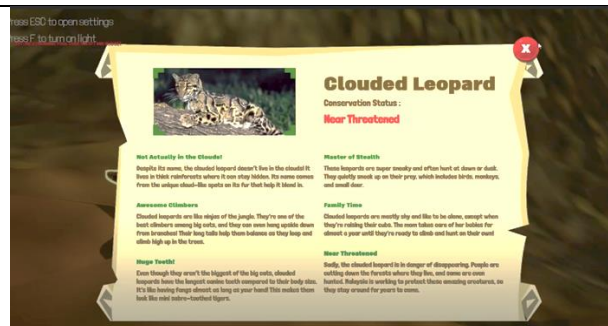
BioScapeMy Interfaces	Descriptions
	Main Menu: This is the entry screen of the game, where players can access different game options, including game levels, journals, quiz and games settings.
	Game Settings: In this interface, players can adjust the level of the sounds, get information on how to play the games, terms of service and privacy policy.
	Game Levels: This game contains three level of difficulties. each featuring unique challenges and environments inspired by Malaysia's wildlife. To make the game more engaging, each level has different numbers of animals and plants. As the games progress to higher level, the visibility of the drone camera become more challenging e.g. level 1 involved exploring the jungle in broad daylight, while at level 2, players will have to search for the animals/plants in night mode. The timer also will make the game more challenging for players as they need to find their target as soon as possible.
	Game Mission: At every level of the game, players will be given a mission to allocate a number of animals and plants in the wildlife environment. These numbers of animal or plants increase as the player reaches higher level of the game.



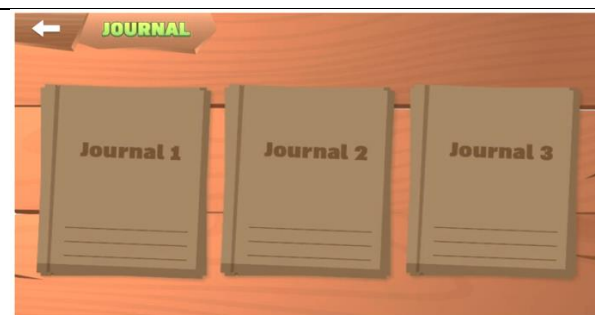
Drone Exploration: As the exploration begins, players will control and fly the drone to search for the specific targeted animal or plants assigned in the mission.



Drone interaction: When the players found the targeted species that have been specified, a glow effects will appear around the animals or plants indicating the correct and successful discovery. Next, player will have to press button 'E' to extract the information from the game.



Pop-up Information: After players press the 'E' button, a pop-up displays information about the discovered species, their conservation status (e.g. threatened/near threatened) and conservation efforts needed. This journal entry not only introduces players to the species in engaging way but also subtly teaches wildlife behavior, ecological roles, and conservation challenges, blending gamified learning with real-world environmental awareness.



Post-game Journal: This is a dedicated section where all collected information about the animals / plants found during in the games are stored. Players can revisit journal entries anytime, with content limited to the discoveries made in each level.



Mission Completed Interface: Players will be given a summary of their performance upon completing a game level. The information would include key statistics, i.e. the time taken to complete the mission, the total area explored by the drone, the best completion time recorded, and the number of required animals or plants successfully collected. This feedback helps players track their progress and improve their performance, enhancing the gaming experience by providing clear performance metrics and encouraging replayability through challenges such as improving completion time and maximizing collections.



Quiz: For each level there will be a Post-game Quiz. For example, Quiz 1 is referring to exploration for level 1, assessing players knowledge about the animals and plants they have found in Level 1.



Quiz questions: This is example of quiz interface and questions asked are in the form of multiple-choice questions. Players need to answer a total of 10 questions at each level. They need to get 100% correct to unlock the next level of the exploration. To help players answering this quiz, players can revisit the journal section to recall the information about the animals/plant they had found.

3.3.2 The User Evaluation

User testing was conducted to assess the effectiveness of the game in enhancing awareness of wildlife conservation. The following subsections described in detail how our participants were recruited and how the evaluation was conducted.

i) Participant Recruitment

To ensure a meaningful evaluation, participants were selected based on specific inclusion criteria which include (a) prior exposure to topics related to ecosystems and biodiversity in their school curriculum, (b) demonstrating an interest in wildlife, (c) have general knowledge of Malaysia's flora and fauna, and (d) have basic gaming proficiency. These criteria were established to ensure that our participants have the necessary background to effectively engage with our drone-simulated 3D game. Potential participants who were believed to meet the inclusion criteria were personally invited to

take part in the study. Upon their agreement to participate, a testing session was scheduled at a mutually convenient time to facilitate smooth participation.

ii) Procedures

Our user testing procedures were structured into three distinct phases: (1) Pre-test, (2) Intervention, and (3) Post-test. For Phase 1 (Pre-test), participants were asked to answer a set of questionnaires (Baseline Assessment) aimed to evaluate participants' initial awareness understanding and motivations towards Malaysia's wildlife, biodiversity, environmental threats, and conservation efforts. The assessment consisted of five statements, and participants were asked to give ratings based on a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree). Establishing this baseline was essential for measuring any knowledge gains resulting from gameplay.

For Phase 2 (Intervention), participants were asked to engage with the game to assess its functionalities and mechanics. To ensure a comprehensive evaluation of all the game's features, a structured list of tasks was provided to participants to guide them in exploring the game. The tasks include testing drone navigation using keyboard and mouse controls, verifying the functionality of the in-game journal and quiz features, assessing overall game performance, including audio-visual quality and game responsiveness. This phase allowed participants to explore the game in-depth while providing feedback on usability and system performance.

After the completion of all tasks, Phase 3 (Post-test) began as the participants were asked to complete an Impact Assessment questionnaire designed to evaluate whether the game had effectively enhanced their awareness of wildlife conservation. This phase aimed to determine the extent to which the game met its design objectives. Additionally, participants were also asked on their perceptions regarding the usefulness of *BioScapeMY* to enhance awareness towards wildlife conservation. All user testing sessions were conducted in a face-to-face setting to ensure the accuracy and reliability of the results. In-person testing also allowed us to observe participants' interactions and emotional responses in real-time, facilitating immediate feedback collection and behavioural analysis. Furthermore, any technical issues, such as hardware-related errors, could be promptly identified, documented, and addressed during the session, ensuring a seamless testing process.

4 RESULTS AND DISCUSSIONS

A total of five participants participated in our user testing. They were primarily consist of 17-year-old female secondary school students, studying science subjects that cover topics related to ecosystems and biodiversity. Their educational background provides them with foundational knowledge about Malaysia's natural environment, making them suitable for the study. Additionally, all the participants also self-reported being familiar with digital tools and basic gaming mechanics, which helped in quickly familiarize themselves with interaction with the game. Although the number of participants is small, according to Nielsen [13], conducting user testing with five participants is generally considered sufficient for identifying the majority of usability issues in a system. This approach allows for iterative testing and refinement, optimizing resource utilization. The following Table 5 presents the results of the Pre-Test Baseline Assessment and Post-Test Impact Assessment.

Table 5 : Result of Pre-Test Baseline Assessment.

No.	Statement	Mean, <i>M</i>	
		Pre-test	Post-test
1	I have a comprehensive understanding of Malaysia's diverse wildlife and rich biodiversity.	4.2	5.0
2	I am aware about the major threats facing Malaysia wildlife, including deforestation and illegal wildlife trade.	4.4	5.0
3	I am knowledgeable about Malaysia's endangered species and their ecological significance.	4.8	5.0
4	I find educational resources on wildlife conservation to be engaging and effective to enhance my understanding.	4.4	5.0
5	I feel motivated to further explore biodiversity and actively participate in conservation efforts.	5.0	4.8

Based on the above Table 5, the pre-test and post-test results indicate a significant improvement in participants' knowledge, awareness, and engagement with Malaysia's wildlife conservation after experiencing our drone-simulated 3D game, *BioScapeMY*. The increase in mean scores across most statements suggests that the interactive and immersive nature of the game effectively enhanced conservation-related learning outcomes.

One of the most notable improvements is observed in Statement 1 ("I have a comprehensive understanding of Malaysia's diverse wildlife and rich biodiversity"), which increased from a mean score of 4.2 to 5.0. Similarly, Statement 2 ("I am aware of the major threats facing Malaysia's wildlife, including deforestation and illegal wildlife trade") also increased from a mean score of 4.4 to 5.0. These findings suggest that *BioScapeMY* was particularly effective in raising factual knowledge and awareness. According to Fitrianto and Saif [14] students demonstrated higher levels of participation, deeper understanding of complex concepts and improved retention of knowledge in immersive environments compared to traditional methods.

A slight improvement is also observed in Statement 3 ("I am knowledgeable about Malaysia's endangered species and their ecological significance"), where the mean score increased from 4.8 to 5.0. This suggests that, through interactions with *BioScapeMY* participants gained a deeper understanding of specific species and their roles in maintaining ecological balance. This finding is aligned with research by Wang et al. [15] which highlights that gamification in education enhances knowledge retention and cognitive engagement.

Furthermore, the mean score for Statement 4 ("I find educational resources on wildlife conservation to be engaging and effective") also increased from 4.4 to 5.0, indicating that participants perceived the *BioScapeMY* as an effective and engaging educational tool. A systematic review by Hajj-Hassan et al. [16] on the use of digital tools for environmental education supports this finding stating that, incorporating multimedia, gamification, and simulations into sustainability education can enhance its effectiveness, and make it more engaging and interactive. Similar findings were reported by another study by Tan and Nurul-Asna [17] which found serious games designed for environment

education would be successful if they included an immersive experience, meaningful engagement, a learn-by-doing involvement and simulation of real-world environmental problems.

However, an interesting observation is seen in Statement 5 ("I feel motivated to further explore biodiversity and actively participate in conservation efforts"), where the mean score slightly decreased from 5.0 to 4.8. While the decline is minimal, this may be attributed to participants' unfamiliarity with the assigned tasks. For instance, exploring and navigating the 3D environment using drone controls, identifying species, and managing journal entries can be overwhelming for novice users particularly those with no prior experience in drone maneuvering. To address this, implementing progressive tutorials, staged onboarding, or context-sensitive hints could help gradually manage task complexity and improve accessibility of the game.

The following Table 6 present the results of user evaluation on game functionalities and mechanics.

Table 6: Results on User Evaluation on Game Functionalities and Mechanic.

No.	Item	Mean, <i>M</i>
1	The BioScapeMY interface is usable and easy to navigate.	5.0
2	The controls and mechanics of BioScapeMY are intuitive and straightforward.	5.0
3	The 3D environments and graphics in BioScapeMY enhance my gaming experience	4.6
4	The instructions and objectives inside BioScapeMY are clear.	5.0
5	The gameplay of BioScapeMY is engaging and holds my attention throughout.	5.0
6	The quizzes in BioScapeMY are informative and appropriate for learning.	5.0
7	The BioScapeMY performance (e.g., loading times, smoothness of the transitions) is satisfactory.	4.6
8	I encountered minimal to no bugs or glitches during gameplay.	4.2
9	BioScapeMY effectively combines fun and learning.	5.0
10	The background music and sound effects in BioScapeMY contribute to a better gaming experience.	5.0

Based on Table 6 above, the game interface was rated highly usable ($M = 5.0$), with controls and mechanics described as intuitive. This finding aligns with studies emphasizing the importance of well-designed user interfaces in educational games, where ease of navigation enhances learning engagement [18]. Moreover, the clarity of objectives and instructions ($M = 5.0$) ensures that players can seamlessly progress through the game without confusion – an essential factor in game-based learning. The gameplay experience was also rated exceptionally well, with engagement ($M = 5.0$) and the integration of fun and learning ($M = 5.0$) receiving perfect scores. These findings reinforce previous research indicating that interactive and immersive digital environments improve user engagement and motivation in serious games [16, 17].

While the 3D environments and graphics were positively rated ($M = 4.6$), two of our participants rated them slightly lower (4.0). This suggests that while the visuals enhance the gaming experience, there may be room for graphical refinements, such as improving textures, animations, or

environmental realism. This finding is consistent with Martinez et al. [19] which highlights that high-quality 3D visuals significantly impact immersion, particularly in educational simulations.

Similarly, game performance and technical issues ($M = 4.2$) received slightly lower scores ($M = 4.6$ and $M = 4.2$) respectively, indicating occasional minor glitches. This finding is consistent with research by Politowski et al. [20], which emphasizes how important smooth performance and bug-free experiences are to games' success. Besides, optimizing loading times and refining game transitions also would contribute to enhance user satisfaction.

The background music and sound effects were highly appreciated as all participants gave a score of 5, ($M = 5.0$), supporting studies on the role of audio cues in immersive learning and engagement [21]. Additionally, the quizzes ($M = 5.0$) were deemed informative and appropriate, reinforcing research that highlights interactive assessments as effective learning tools [22].

In summary, the results of user evaluation on *BioScapeMY* functionalities and game mechanics indicate that the game had successfully balances usability, engagement, and learning effectiveness. However, minor technical and graphical improvements could further enhance user experience. Future iterations of the game could focus on optimizing 3D graphics, improving performance stability, and minimizing technical glitches to ensure an even smoother experience.

Additionally, we also asked user perceptions regarding the usefulness of *BioScapeMY* to enhance youth awareness towards wildlife conservation. The following Table 7 presents the results.

Table 7: User perceptions on Usefulness of BioScapeMy.

No.	Statement	Mean, M
1	I believe <i>BioScapeMY</i> has increased my awareness of wildlife conservation issues.	5.0
2	Through my interactions with <i>BioScapeMY</i> , I have gained new knowledge about wildlife conservation efforts and endangered species.	5.0
3	The educational content in <i>BioScapeMY</i> is clear, engaging, and effectively explains the importance of wildlife conservation.	5.0
4	I believe <i>BioScapeMY</i> is an effective tool for educating youth about wildlife conservation.	5.0
5	I would recommend <i>BioScapeMY</i> to others who are interested in learning about wildlife conservation.	5.0

Based on the above table 7, the results demonstrate that *BioScapeMY* is perceived as a highly effective tool for wildlife conservation awareness. The high ratings for statements related to increased awareness (Statement 1) and knowledge acquisition (Statement 2) align with previous research indicating that digital and immersive learning tools significantly enhance users' understanding of environmental issues [12]. Studies have shown that interactive educational platforms, particularly those incorporating gamification and simulation elements, improve cognitive engagement and retention of conservation-related information [13]. This suggests that *BioScapeMY* successfully utilizes digital education strategies to communicate complex ecological concepts effectively.

Furthermore, the unanimous agreement on the platform's clarity and effectiveness in educating youth (Statements 3 and 4) highlights the growing role of digital technology in conservation

education. Prior research has emphasized that digital learning environments can bridge knowledge gaps by making conservation education more accessible and interactive [14]. Additionally, the strong recommendation rate (Statement 5) indicates that users perceive *BioScapeMY* as a valuable resource worth sharing, which could contribute to broader public engagement in wildlife conservation.

This user evaluation revealed overwhelmingly positive perceptions regarding the usefulness of *BioScapeMY* in promoting wildlife conservation awareness among youth. As shown in Table 8, all five evaluated statements received a perfect mean score of 5.0, indicating unanimous agreement among participants. Users reported increased awareness and knowledge of wildlife conservation issues, praised the clarity and engagement of the educational content, and affirmed the game's effectiveness as a learning tool. The unanimous intent to recommend the game further reflects its perceived value and potential for broader outreach.

These findings align with existing research supporting the efficacy of interactive and gamified educational tools in enhancing environmental awareness. *BioScapeMY* appears to successfully leverage digital learning strategies to communicate complex ecological concepts in an accessible and impactful manner.

However, while the initial user feedback is promising, further research is necessary to evaluate the long-term educational impact of *BioScapeMY* and its effect on wildlife conservation behaviors. Longitudinal studies would be particularly useful in understanding the game's ability to support lasting knowledge retention and drive long-term changes in attitudes. Additionally, comparative research with other conservation education methods, such as traditional classroom teaching or community outreach initiatives, would help identify the most effective strategies for environmental education. A more diverse and larger sample, representing various educational backgrounds and geographic regions, would also strengthen the generalizability of the findings. Regarding game features, 3D drone-simulation games designed for conservation education could benefit from progressive tutorials or context-sensitive tips to ease task complexity for novice users, improving accessibility and engagement. This would be especially helpful for users unfamiliar with the game mechanics or drone maneuvering. Furthermore, analyzing in-game data and user interactions could provide valuable insights into how specific gameplay elements influence learning outcomes.

5 CONCLUSIONS

This research has explored the potential of *BioScapeMY*, a drone-simulated 3D games as an immersive tool for wildlife exploration and conservation awareness. By integrating drone technology with 3D game environments, this study highlights how interactive simulations can enhance engagement, learning, and awareness of ecological and conservation issues. The findings suggest that such simulations provide users with an enhanced sense of presence, enabling them to experience wildlife ecosystems in ways that traditional media cannot offer. The study also demonstrates the importance of immersive learning experiences in conservation education. The ability to explore realistic wildlife habitats in a simulated environment fosters empathy and a deeper understanding of conservation efforts, particularly among younger audiences who are accustomed to interactive and gamified learning experiences. In conclusion, *BioScapeMY* represents a promising and innovative

approach to wildlife conservation education. Future research should focus on refining this technology, assessing their long-term impact on user behavior, and exploring their integration with real-world conservation initiatives. By leveraging the power of immersive simulations, we can inspire a new generation of conservation advocates and foster a deeper appreciation for the wildlife biodiversity.

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