

Creative Visualization of Marine Life through 3D Animation as a Communication Medium for Preservation: A Case Study of Pulau Payar Marine Park, Malaysia

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ABSTRACT

This research about creative visualization of marine life using Three-Dimensional (3D) animation as a communication medium to enhance awareness, understanding, and immersive experience of marine ecosystems, focusing on Pulau Payar Marine Park, Malaysia. Data were collected through participant observation (underwater photography and video) and expert interviews in marine biology, conservation, underwater photography, and 3D animation. Thematic analysis identified key patterns, including the diversity of tropical species such as soft corals, hard corals, and ornamental fish, and their integration into the animation development process. The animation pipeline included field data collection, 3D modeling, texturing, rigging, rendering, and final animation, producing realistic visual representations aligned with scientific data. Findings show that 3D animation effectively conveys complex information in an engaging, interactive, and understandable way. While challenges remain regarding cost, time, and audience accessibility, exploring future technologies such as AR, VR, and MR can further enrich educational experiences and support marine biodiversity conservation.

KEYWORDS: Creative visualization, Marine life, 3D animation

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1. INTRODUCTION

The Sustainable Development Goal 14 (SDG 14), "Life Below Water," emphasizes the importance of protecting and conserving marine ecosystems to ensure biodiversity balance and the survival of life on Earth. However, according to Reef Check Malaysia (2024), coral reef health has declined, with 63% of surveyed areas recording a decrease in Live Coral Cover (LCC), compared to 45.87% in 2023. Nearly 90% of locations were also affected by large-scale coral bleaching. Key contributing factors include unsustainable tourism, pollution, fishing activities, and potential poaching, despite the survey areas being located within Marine Protected Areas (MPAs). Therefore, efforts to raise public awareness of the importance of marine conservation have become increasingly urgent, particularly among the younger generation.

Pulau Payar, which was gazetted as a Marine Park in 1994, faces similar challenges. Various studies have been conducted in this area, including assessments of reef health during the COVID-19 pandemic (Ismail

et al., 2024b), the effectiveness of artificial reefs as marine habitats (Ramli et al., 2016), and evaluations of recreational and tourism values (Lim & Osman, 2023). However, all these studies primarily focused on biological, ecological, and economic aspects. In terms of information dissemination, conservation efforts in Pulau Payar remain limited to conventional formats such as guidebooks, diving tourism brochures, and basic documentary videos. Even though there are visual records such as photographs and videos taken by local divers, these materials are rarely integrated into interactive educational platforms. This passive form of communication is less engaging and makes conservation messages difficult to capture the attention of younger audiences.

Animation has emerged as one of the most effective mediums for conveying knowledge and experiences visually, including in the field of marine life (Fitriasari et al., 2021). As an innovative and dynamic form of communication, animation can depict marine ecosystems with a high degree of realism, appeal, and accessibility across various segments of society (Wang et

al., 2024). Moreover, the advent of the Fourth Industrial Revolution (IR 4.0) has introduced advanced tools and techniques that allow the creation of highly realistic, interactive, and immersive visual experiences (Pitana et al., 2022). These technologies enable animators to produce more complex and realistic visuals, thereby enhancing animation quality (Virginia, 2022). Consequently, the use of visual media such as animation has a significant impact on raising public awareness and communicating environmental messages (Pratama & Carrollina, 2020).

The concept of creative marine visualization combines artistic ability with technological innovation to illustrate and interpret marine life, thereby fostering deeper awareness, appreciation, and an immersive experience that closely resembles reality. The beauty of the ocean is evident through its diverse species, stunning habitats such as colorful coral reefs, and ecosystems rich in biodiversity (Gumelar & Al-Fatih, 2021). This visualization is not only captivating but also serves as a source of inspiration across various fields, including art, photography, and documentaries. However, observing underwater visualizations is not without challenges, as there are numerous protocols and obstacles to overcome.

Thus, animation functions not only as an effective educational tool but also as a means to engage younger generations, who are often less exposed to passive traditional media such as books, brochures, and basic documentaries, by presenting information in a more interactive and enjoyable manner. Furthermore, animation is now one of the most popular forms of entertainment worldwide, spanning across cultures and social groups, and is no longer limited to children, but is also appreciated by adolescents and adults (Adinda et al., 2022). Despite its global reach, large-scale animation has not yet been fully utilized by conservationists (Yong et al., 2011). Therefore, there is great potential to develop 3D animation as an interactive and creative educational tool, particularly in study areas such as Pulau Payar, to enhance awareness, interest, and understanding among young people regarding marine life conservation, while complementing existing traditional approaches.

2. LITERATURE REVIEW

2.1 Exploration of Creative Visualization for Preservation

3D animation is an effective communication medium today in conveying information and experiences to various levels of society. This is where several key aspects include visual appeal and the ability to convey complex information. 3D animation has a strong visual appeal, which can capture the attention of the audience in a way that traditional media cannot. The use of color, shape, and movement in 3D animation creates

an interesting visual experience and can increase audience engagement (Amali, 2023).

The artist's approach in creative visualization of marine life as a shared science uses art to increase awareness and understanding of marine ecosystems and the challenges they face. Through the use of 3D animation, marine life can be displayed realistically, making it more attractive and accessible to the public (Kendall-Bar et al., 2021). Animation not only conveys complex information visually, but also has the potential to arouse emotions and a sense of responsibility for environmental conservation.

Creative exploration of marine life visualization involves the use of artistic and technological techniques to depict and disseminate knowledge about marine ecosystems in an engaging and effective way. In this context, visualization encompasses not only graphics and illustrations, but also art, multimedia, and interactive technologies that can capture the attention of the public (Witabora & Homan, 2021). Through the use of 3D modeling techniques, animation, and interactive visualization, artists and conservation practitioners can create compelling narratives that depict the beauty of nature as well as the threats faced by endangered species and their habitats.

In the context of creative marine visualization, interactive technologies such as Augmented Reality (AR), Virtual Reality (VR), and Extended Reality (XR) have opened new opportunities in education and conservation communication. These technologies offer immersive learning experiences by allowing users to directly interact with virtual environments that closely resemble real-life settings. Although immersive technologies provide unmatched advantages in terms of interactivity, their use remains limited due to the need for specialized equipment, high development costs, and low accessibility. In fact, such technologies often rely on specific setups such as head-mounted displays (HMDs) for VR or augmented environments for AR, which can be significant barriers in many educational contexts (Turhan & Gümüő, 2022). In contrast, 3D animation is more flexible, cost-effective, and easily accessible through various media such as television, computers, smartphones, or museum exhibitions without the need for additional devices (Sofiana et al., 2023; Azzahra et al., 2024).

Therefore, 3D animation plays a crucial role in creative marine visualization because of its flexibility, accessibility, and suitability for research and educational purposes in Malaysia. At Pulau Payar, which is renowned as a Marine Park and a popular marine tourism destination, the main challenge lies in raising public awareness about the importance of preserving coral reef ecosystems and marine biodiversity without imposing high technological or financial burdens. 3D animation addresses this

challenge effectively, as it can be developed in the form of videos or digital visual models that are easily accessible through multiple platforms such as television, computers, smartphones, or museum exhibitions, without requiring additional devices such as VR headsets or AR applications. Furthermore, 3D animation also serves as a valuable permanent documentation tool, as it can be archived in the form of animated videos, infographic animations, or interactive clips suitable for long-term educational and research reference.

2.2 Definition of Animation

Animation is a medium that allows images to form a movement. Animation is defined as a series of drawings or phrases of movement which when projected onto a screen will produce an illusion of movement (Kaminsin & Achin, 2020). Animation also includes the production of artificial illusions in inanimate movement such as still images. Walt Disney explained that animation can explain, visualize, and reveal what the human mind thinks (Herhuth, 2017). Every individual wants to visualize their experiences and imagination, but still needs to adhere to the established principles of art. In animation, imagination can be applied narratively or symbolically without being bound by logic, allowing visualization outside the box of thinking. Animation has no limits in the development of ideas, making it a medium that can realize anything creatively.

The production of an animation has 12 principles of how to produce a better and more effective animation presented by s Disney, Frank Thomas & Ollie Johnston. The 12 principles of animation were introduced through a book entitled "The Illusion of Life: Disney Animation" (Ribeiro & Paiva, 2012). The principle is a procedure for how the production of an animation is produced successfully and is more interesting and able to convey the purpose of the animation produced. Among those principles are Squash and Stretch, Anticipation, Staging, Straight Ahead and Pose-to-Pose, Follow-Through and Overlapping Action, Slow In and Slow Out, Arcs, Secondary Action, Timing, Exaggeration, Solid Drawing, and Appeal.

In the context of this study, the definition and principles of animation are applied to creatively and realistically visualize the marine ecosystem of Pulau Payar. Located in Kedah, Pulau Payar is a Marine Park rich in biodiversity, including various species of fish and coral reefs. However, threats such as coral damage, pollution, and uncontrolled tourism activities have compromised the sustainability of this habitat. Through the development of 3D animation based on Disney's animation principles, fish species, corals, and the marine environment of Pulau Payar can be depicted more accurately, attractively, and interactively. This creative visualization not only conveys conservation messages more effectively but also has the potential to enhance

awareness, engagement, and public understanding of the importance of marine conservation at Pulau Payar.

2.3 Importance of 3D Animation to Marines

3D animation plays an important role in the marine field, especially in studies, research, and education. This technology allows the creation of realistic models of marine life, as well as underwater ecosystems that are difficult for humans to access. Access to underwater ecosystems faces major challenges such as level, depth and pressure of water, which require specialized equipment and advanced technology for research (Erič et al., 2013). Low visibility due to light scattering and particles in the water also makes it difficult to observe and collect accurate data (Li et al., 2024). In addition, unpredictable weather conditions and strong ocean currents limit access to certain areas, making research in these locations risky (Nkenyereye et al., 2024). A study conducted by Irschick et al. (2020), showed that 3D modeling can be used to create accurate representations of marine mammals such as porpoises, which in turn helps in understanding the morphology and behavior of the species. This approach allows researchers to mimic the shape and movement of living marine animals, especially those that are rare or difficult to capture or photograph and video and manipulate. By creating accurate 3-dimensional models, scientists can indirectly study the anatomy, behavior, and interactions of marine life in a detailed and precise manner.

Advances in 3D modeling and imaging technologies have allowed researchers to create better visual representations of underwater ecosystems, which in turn helps in the effective conservation and management of marine resources (Skarlatos et al., 2021). Therefore, although access to underwater ecosystems is challenging, modern technology provides opportunities to explore and understand this rich and complex world in greater depth.

Previous studies in Pulau Payar have largely focused on biological, ecological, and economic aspects, such as assessments of reef health during the COVID-19 pandemic (Ismail et al., 2024b), the effectiveness of artificial reefs as marine habitats (Ramli et al., 2016), and evaluations of recreational and tourism value (Lim & Osman, 2023). However, these studies remain scientific and quantitative in nature, without emphasizing the need for more interactive conservation communication targeted at the general public.

From the perspective of information dissemination, conservation efforts in Pulau Payar still rely on traditional media such as guidebooks, brochures, and basic documentary videos. These media are passive in nature and less effective in capturing the attention of younger generations who are more engaged with interactive digital platforms. This is where the role of 3D animation

becomes highly significant. 3D animation not only visualizes Pulau Payar's marine ecosystem in a more realistic way without the risks of actual diving but also creates an interactive, enjoyable, and effective learning experience that can enhance awareness and interest in conservation.

Although animation has been widely applied in the entertainment and education industries globally, its use in the context of marine conservation in Malaysia, particularly in Pulau Payar, has not yet been fully explored (Yong et al., 2011). Therefore, a clear research gap exists namely, the need to develop 3D animation as a medium that serves not only as entertainment but also as an interactive educational tool capable of bridging the gap between marine science and public awareness. This research has the potential to contribute to innovation in conservation communication, particularly by linking animation technology with efforts to preserve local marine biodiversity.

3. METHODOLOGY

The qualitative research approach through participant observation was implemented by taking samples of marine photographs and videos directly while in the field. This method allows researchers to document the actual state of the marine ecosystem and the interactions of marine life in their natural environment. This visual sampling serves as supporting data in qualitative analysis. By recording photographs and videos, researchers can capture important aspects such as the diversity of marine species, the behavioral patterns of marine life, and the structure of coral reefs.

In addition, expert interviews were conducted to obtain in-depth insights from individuals with experience in the field of marine studies and the use of visual technologies such as underwater photography and 3D animation. The selection of experts was carried out through purposive sampling, as they possess specialized knowledge relevant to the objectives of the study. The experts involved included the Fisheries Officer (Head of the Conservation and Fisheries Protection Branch, Kedah), who provided perspectives on policies, regulations, and conservation efforts at Pulau Payar; a marine macrobiology specialist, who emphasized scientific aspects such as biodiversity and marine ecology, a NAUI Instructor in Kedah and the Head Coach of Aqua Space Diving Center, who shared practical experiences in diving, underwater documentation, and technical challenges in recording marine ecosystems in Kedah, while an animation education expert contributed views on the effectiveness of animation as a pedagogical medium for enhancing understanding and awareness, and an animation technical and practical expert highlighted the technical aspects of 3D animation development, including visual realism, character

design, digital environments, and the integration of marine visual elements.

Data obtained from interviews and observations were analyzed using thematic analysis methods. This analysis process involved coding data, grouping related codes, and identifying key patterns and themes that emerged from expert discussions (Rozali, 2022). The researcher identified initial themes by examining overlapping codes and then categorizing similar codes, forming a theme related to the diversity of tropical fish species, 3-dimensional animation as an effective medium, and the importance of 3-dimensional animation in understanding marine life.

To complement the qualitative findings, prototype testing of the developed 3D animation will also be conducted. This evaluation involves distributing questionnaires to selected participants using a Likert scale to measure perceptions of usability, clarity, realism, and effectiveness of the animation. In addition, open-ended questions will be included to gather deeper feedback on users' experiences, suggestions, and critical comments regarding the animation. This combination of quantitative and qualitative feedback ensures that the prototype is not only scientifically accurate but also practically effective in raising awareness and enhancing public understanding of marine conservation.

4. RESULTS

4.1 Observation Participant

Participant observation was conducted in Malaysian waters, specifically in the area around Pulau Payar Marine Park, Kedah. Located on the northwest coast of Peninsular Malaysia, latitude coordinates 6°03'N-6°05'N and longitude 100°02'E-100°04'E, approximately 35 km from the Kedah coast (Ismail & Najib, 2024a). At the location, researchers took video and photo samples to document the natural state of the marine ecosystem and the diversity of life there.

As shown in **Figure 1**, Pulau Payar Marine Park, Kedah, Malaysia. Fieldwork involved participant observations and the collection of marine samples to support the documentation of habitat characteristics in the study area.

Table 1, Table 2, Table 3 and **Table 4** are the results of documentation through underwater photography carried out by the researcher using an Olympus TG6 camera with the help of dive gear during diving activities at the study location. This material will be used as a reference in the production and post-production process.



Figure 1: Pulau Payar Marine Park, Kedah, Malaysia.

4.2 Expert Interviews Based on Field

Semi-structured interviews with informants, consisting of underwater photography experts, marine experts, and 3D visual experts. Each category of informant was labeled as A, B, or C, and each individual was marked with the numbers 1 and 2, to make it easier for the researcher to identify each respondent, as shown in Table 5.

4.2.1 Selection of Marine Subjects in 3D Animation

The first theme that emerged from the data analysis was the selection of marine subjects for the purpose of being used as a reference in the animation production process. The data showed that the source of information that can be used to understand and document marine species at the study location. According to Informant A1, "Based on my experience, if I were to say that these types of fish species are mostly divers, they like fish with lots of young fish, such as yellowtail fish (*Selaroides Leptolepis*), which are school types of fish." In addition, Informant A2 said, "The first diving experience showed the beauty of coral reefs and the diversity of colorful fish". This was further explained by informant B2 regarding the species found at the study location "Pulau Payar has various species of fish. This means that Pulau Payar is one of the best marine parks in terms of fish species and has a variety of reefs". Referring to B1, he explained the factor of species diversity because Malaysia is located in the tropics, which provides advantages in terms of temperature stability throughout the year, suitable for marine life. Therefore, C1 stated that the selection of marine subjects in 3D animation "if it involves science, it really has to be right," as shown in schedules 1,2,3 and 4.

Table 1: List of fish species in Pulau Payar Marine Park, Kedah





Subject	Scientific Name	Description
	<i>Selaroides Leptolepis</i>	It has an oval and flattened body with a metallic blue back color and a bright yellow stripe from eye to tail. The sides of the body are silvery, while the fins are pale yellow or gray, except for the white ventral fin (Sinaga et al., 2018)
	<i>Epinephelus Fuscoguttatus</i>	The dark brown to gray body with bright marble patterns aids camouflage in rocky and coral reef habitats, enhancing hunting and protection from predators (Chan, 2015)
	<i>Heniochus Diphreutes</i>	White body with two black stripes, white filaments on dorsal fin, and yellow fins after the black stripe. White head with black eyes connected by a black stripe. Lives outside reefs and feeds on plankton in groups (Bergbauer & Kirschner, 2014)
	<i>Amphiprion Ocellaris</i>	Maximum 11cm, orange body with broad white markings on head, body, and tail. Central triangular white marking near pectoral fin. Thin black lines on edges of all fins, caudal fin rounded with white tip (Dewi & Harsindhi, 2018)

Table 2: List of hard coral reef types in Pulau Payar Marine Park, Kedah





Subject	Scientific Name	Description
	Acropora Muricata	Colonies are branched with thick, vertical, cascading branches. In shallow water, branches are dense and short. Radial corallites of various sizes and shapes, tubular and elongated at the ends of the branches, resembling axial corallites (Ismail, 2021)
	Porites Lutea	Colonies are round or helmet-shaped, over 2m wide, and may form micro-atolls in intertidal zones. Corallites are thin-walled and more distinctly skeletal than in P. lobata. Colony surface smooth with small lobes (Ismail, 2021)
	Paragoniastrea Australensis	Semi-massive colonies, forming solid or crusted plates, with meandroid shapes and winding valleys. The center of the columella and pali lobes are clearly formed (Ismail, 2021)
	Acropora Hyacinthus	The colonies are table-shaped, up to 4 meters wide, with small vertical branches. The axial corallites are small but can be distinguished from the bowl-shaped radial corallites (Suharsono, 2008)

Table 3: List of soft coral reef types in Pulau Payar Marine Park, Kedah





Subject	Scientific Name	Description
	Melithaea Ochracea	Has a fan-like, branched skeleton. Small polyps on top of the skeleton, which are used to capture plankton from the water. The orange-red color is common in gorgonians (Bergbauer & Kirschner, 2014)
	Anthelia Glauca	The polyps are soft and flexible, allowing them to adapt to their environment. They exhibit high plasticity, increasing their resilience to reef disturbances. The internal structure of these corals supports interactions with zooxanthellae (Bergbauer & Kirschner, 2014)
	Goniopora Tenuidens	Colonies massive, round or irregular, with round thin-walled corallites. Polyps close and uniform, and blunt tentacles of equal length (Bergbauer & Kirschner, 2014)
	Cirripathes Spiralis	A long structure like a whip (whip), can reach several meters in length. Small polyps arranged along the trunk (Bergbauer & Kirschner, 2014)

Table 4: List of macro subjects at Pulau Payar Marine Park, Kedah





Subject	Scientific Name	Description
	Hypselodoris Pulchella	The body is brightly colored with a combination of blue, yellow, and white, serving as camouflage and a warning of toxicity. The body is elongated, soft, and has gelatinous, fleshy projections that aid in respiration and defense (Ryanskiy, 2022)
	Pteraeolidia Semperi	Unique anatomy that supports a symbiotic relationship with photosynthetic algae. Having finger-shaped tentacles that function for respiration, movement, and as a host for the dinoflagellate Symbiodinium (Ryanskiy, 2022)
	Phyllidia Varicosa	The bright colors, with patterns of yellow, blue, black, and white, serve as a warning to predators and aid in camouflage on coral reefs. They are oval and flattened and covered with tubercles, which are glandular structures that secrete toxins for chemical defense (Ryanskiy, 2022)
	Chromodoris Strigata	The flattened body with yellow, orange, and blue patterns serves as camouflage and a warning to predators (Ryanskiy, 2022)

Table 5: Interviews with experts

Category	Description	Participant	Tagging
Underwater Photography Expert	Practitioners with several years of experience in underwater imaging	Underwater photography1	A1
		Underwater photography2	A2
Marine expert	Expert in marine education and conservation	Marine expert 1	B1
		Marine expert 2	B2
3D Visual Expert	Expert in 3D visualization education and practitioners	3D expert 1	C1
		3D expert 2	C2

4.2.2 Importance of 3D Animation in Marine Visualization

3D animation is an effective communication medium today in conveying information and experiences to various levels of society. According to A1, "with 3D animation, everyone, regardless of their level, can enjoy it themselves, can see it even if they cannot dive, but indirectly they can see it through TV or internet media". In addition, referring to B1 and B2, they believe that not everyone has the opportunity to explore the ocean directly. Therefore, 3D animation is an alternative that helps this group recognize

marine organisms, understand their ecosystems, and realize their importance. In addition, according to C2, "animation allows for immersive storytelling that brings viewers as if they are under the sea". Therefore, 3D animation is an effective communication medium that allows all levels of society to enjoy visual experiences, especially for those who do not have the opportunity to explore the ocean directly.

4.2.3 Developing Idea- Pipeline Animation

As illustrated in Figure 2, Pipeline Animation (Ibrahim,

2024) was developed based on field data, participant observations, expert interviews, and marine samples collected at Pulau Payar Marine Park, Kedah, Malaysia. The pipeline consists of three main stages: pre-

production, production, and post-production. Each stage is integrated with empirical data and expert input to ensure scientific accuracy and visual realism of the marine ecosystem.

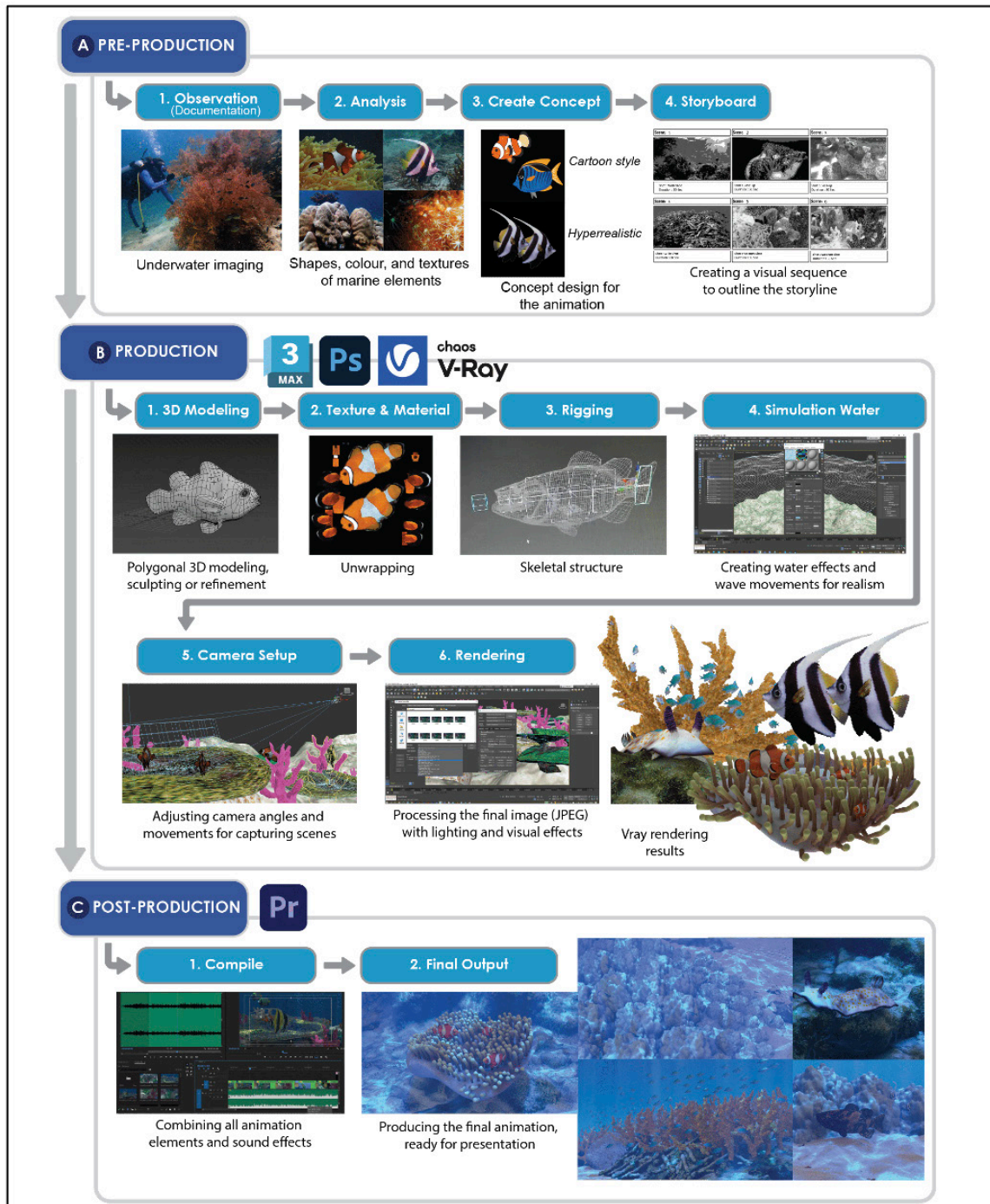


Figure 2: Pipeline animation (Ibrahim, 2024)

(A) Pre-Production, the process started with (1) Observation, which is the Documentation of real marine life, followed by (2) Analysis based on their shapes, color, and the textures of marine elements. Next, the team (3) creates the Concept, designing the overall look and feel of the animation, before developing a (4) Storyboard to plan each scene visually. During the (B) Production, the (1) 3D modeling phase involves creating wireframe models of marine creatures and environments using software like 3ds Max. Second, (2) Texturing and Material application are done using Photoshop and V-Ray to enhance more realism animation. In (3) Rigging phase, will add the skeletons and controls to the models for movement. (4) The Simulation Water phase process on creating water effects and the movements of waves make it more realistic or realistic water effects, while (5) Camera Setup establishes or adjusts camera angles the movements for capturing scenes. Finally in the (6) Rendering phase will be processing the final image or all elements with adding some lighting and visual effects into high-quality frames. In (C) Post-Production, the rendered frames will be compiled and edited using Adobe Premiere Pro which is the final touches, such as sound design and visual enhancements, will be applied in realism animation. The end result is a polished Final Output, showcasing an immersive underwater animation with realistic textures, lighting, and movement. This structured workflow ensures a high-quality marine life animation, blending scientific accuracy with creative storytelling.

Field observations at the study site through photographic and video recordings did not merely document the diversity of fish species and coral reefs in Pulau Payar, but also directly influenced design decisions within the 3D animation pipeline. For example, visual recordings of schooling fish such as *Selaroides Leptolepis* (yellowtail scad) served as the basis for developing more convincing schooling behaviour in the animation. Similarly, variations in the colors, textures, and forms of corals obtained from underwater photography were applied in the modelling and texturing phases to ensure that visual realism closely resembled actual conditions. Expert interviews also emphasized the need to preserve scientific accuracy, which shaped the choice of color palettes and species morphology, while the insights of experienced divers helped refine the dynamic movements of marine life to align with real ecosystem conditions. Thus, it can be explained that field data and expert input not only functioned as supplementary references but also formed the foundation guiding the animation pipeline in terms of modelling, texturing, coloring, and movement simulation. This integration demonstrates that the resulting animation is not merely aesthetic but is grounded in strong scientific and empirical foundations.

4.3 Respondent Feedback and Evaluation

This section discusses the feedback and evaluation from respondents regarding the 3D marine animation prototype developed based on the marine ecosystem of Pulau Payar, Kedah. Data were collected through an academic visit by students to the Faculty of Applied and Creative Arts, UNIMAS, involving 50 students aged 17 years from SMK Kalaka, Roban, Sarawak. The visit provided the students with an opportunity to experience the 3D animation firsthand, which visualizes the real conditions of Pulau Payar's marine ecosystem, including issues such as coral reef degradation and restoration efforts.

Respondent feedback was collected to assess two main aspects. First, the effectiveness of the 3D animation in raising awareness of the importance of marine conservation, by examining how visualizations of coral damage and restoration at Pulau Payar impacted their understanding. Second, the suitability of 3D animation as an educational and knowledge-sharing medium, that is, whether the animation can effectively convey information and enhance understanding of Pulau Payar's marine ecosystem to the general public. The findings from Section B (Accessibility & Usability), Section C (Engagement & Interactivity), and Section D (Overall Experience) further support this evaluation, showing that 3D animation is not only effective in raising awareness about the importance of marine conservation through its depictions of coral damage and restoration, but also suitable as a medium for sharing marine knowledge with the wider community.

As shown in **Figure 3**, students from SMK Kalaka, Roban, Sarawak, participated in an academic visit to the Faculty of Applied and Creative Arts, UNIMAS, where they previewed the 3D marine animation (**Table 6**). The visit provided the students with an opportunity to experience the 3D animation.



Figure 3: Preview 3D marine animation.

4.3.1 Effectiveness of 3D Animation in Raising Awareness of Marine Conservation

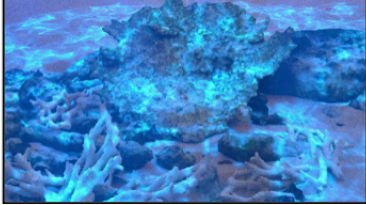
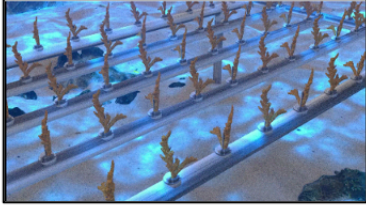
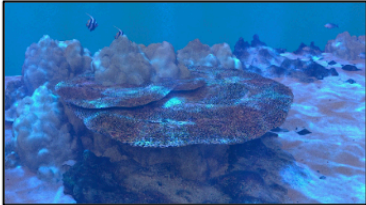



Based on the findings, the majority of respondents indicated that the 3D animation display is effective in raising awareness of the importance of marine conservation. This is evident in Section D, where 36 respondents strongly agreed and 14 agreed that the

animation helped them better understand marine biodiversity. In addition, 35 respondents strongly agreed and 15 agreed that they became more aware and concerned about marine conservation after watching the animation.

In Section C, 24 respondents strongly agreed and 17 agreed that the multimedia elements (visuals, audio, and

narration) were relevant to the conservation message. Open reflections also revealed that respondents felt more aware when viewing depictions of damaged coral reefs and restoration efforts, as these provided a realistic picture of threats to the marine ecosystem. Some respondents noted that the animation was "easy to understand, realistic, and capable of raising awareness even at a global level."

Table 6: A Scene from the 3D Animation Marine

Scene	Description
	Shows the condition of coral reefs that are damaged or dead. This highlights the issue of marine ecosystem destruction caused by natural factors or human activities, raising awareness of the importance of conservation.
	Depicts conservation efforts through coral planting, focusing on staghorn corals in a nursery setup. This represents human intervention to restore marine habitats.
	Represents a coral structure that can serve as a habitat for various marine species.
	Highlights a shoal of yellowtail scad swimming together. This collective movement represents the richness of marine biodiversity and conveys the vitality of a thriving underwater ecosystem.
	Displays bannerfish swimming around the coral
	Close-up or macro shot of a small marine creature (nudibranch). This scene highlights the uniqueness and beauty of the species at a close scale, adding both aesthetic and scientific value to the visualization.

4.3.2 Suitability of 3D Animation as a Medium for Sharing Marine Knowledge with the Public

The findings show that 3D animation is considered suitable and effective as a medium for knowledge sharing. In Section B, 22 respondents strongly agreed and 15 agreed that they could access marine-related information (species, corals, and the marine environment) without difficulty. Furthermore, 20 respondents strongly agreed and 17 agreed that the visual design of the animation supported their learning experience.

Sections C and D further reinforced this perspective. 24 respondents strongly agreed and 19 agreed that they were more engaged with 3D animation compared to static text or images, while 34 strongly agreed and 16 agreed that they would recommend this animation as a learning medium to others.

The open reflections supported these quantitative findings. Many respondents commented that the 3D animation was "easy to understand, appealing to all age groups, interactive, and clear in delivery." Some also emphasized that 3D animation is suitable for the public because it presents knowledge in a modern, engaging way that aligns with the visual preferences of the younger generation.

Overall, the findings indicate that 3D animation is both effective in raising awareness about marine conservation and suitable as a medium for sharing knowledge with the public. Respondents agreed that the realistic visuals of coral reef damage and restoration increased their understanding and concern for marine ecosystems. At the same time, they found the animation easy to access, engaging, and supportive of learning, making it a relevant and appealing tool for modern education and public awareness.

5. DISCUSSION

The 3D marine animation developed based on Pulau Payar Marine Park, Kedah, demonstrates how field data and expert input can be translated into accurate digital visualizations of real marine ecosystems. This study supports previous findings that identify animation as a highly effective medium for conveying information and visual experiences, particularly within the context of marine life education (Fitriasari et al., 2021). Fieldwork activities such as participant observation, underwater photography, video recording, and marine sampling provided detailed information that directly informed the design decisions throughout the animation pipeline. For example, the schooling behaviour of *Selaroides leptolepis* was incorporated to produce more realistic movement simulations, while the diverse textures and colors of coral reefs were applied during the modelling and texturing stages.

This approach is consistent with earlier studies highlighting that access to marine ecosystems is often limited due to environmental challenges such as depth, water pressure, equipment constraints, and reduced visibility (Erič et al., 2013; Li et al., 2024). Therefore, 3D animation not only overcomes these limitations but also provides stable and analytically useful scientific representations. Research by Irschick et al. (2020) further demonstrates that 3D modelling can accurately capture species morphology and movement, strengthening the scientific justification for the animation developed in this study.

Feedback from 50 students during an academic visit to the Faculty of Applied and Creative Arts, UNIMAS, reinforces the educational value of the animation. The students reported improved understanding of coral reef conservation issues after viewing the animation, aligning with research showing that immersive visualization can enhance learning and environmental awareness. Moreover, animation as a contemporary medium is more capable of engaging younger audiences compared to passive traditional media such as books, brochures, or basic documentaries (Adinda et al., 2022). This is significant because younger generations tend to respond more positively to interactive and enjoyable forms of visual communication.

From an industry perspective, technological advancements such as high-performance rendering, realistic modelling, and modern animation software now allow the creation of more complex and visually convincing outputs (Virginia, 2022). This means that 3D animation can function not only as an educational tool but also meet the visual standards of the global creative industry (Wang et al., 2024). However, despite animation being one of the most popular entertainment mediums worldwide, its application in conservation remains underutilized by conservation practitioners (Yong et al., 2011). Thus, the development of 3D animation in this study opens new avenues for supporting marine conservation activities through creative and interactive approaches.

Overall, the integration of field observations, expert insights, previous research, and user evaluation demonstrates that 3D animation can serve as an accurate scientific representation of marine ecosystems. This visualization method not only adds value to research and education but also enhances youth engagement and awareness regarding marine conservation. This approach aligns with existing literature emphasizing the significant role of animation as a pedagogical tool, a means of scientific communication, and an effective knowledge-transfer medium, thereby highlighting its broader potential for application in Pulau Payar and other ecological studies in the future.

6. CONCLUSION

This research analyzes the effectiveness of 3D animation in creatively and realistically visualizing the ocean. Scientific accuracy is ensured through the use of real-world data and academic references, allowing elements such as fish movement, light reflection, and current simulations to be depicted realistically. The selection of appropriate marine species, including schooling fish and coral reefs, further enhances the visual appeal of the animation. The results demonstrate that 3D animation is an effective communication medium, enabling individuals to virtually experience exploring the seabed.

Challenges in animation production can be addressed through real-time rendering and 3D modeling technologies that support scientific data, along with close collaboration between animators and marine experts to improve accuracy and quality. Future studies may explore the use of immersive interactive technologies to enhance the ocean exploration experience in other locations, while enriching narrative elements and providing users with an experience akin to actually being on the seabed.

The study successfully achieved its objectives through a combination of field observation, expert interviews, and the 3D animation pipeline. This approach not only improved the accuracy and quality of the animation but also established 3D animation as an effective medium for educating the public and raising awareness about the importance of marine conservation.

In conclusion, creative visualization of marine life through 3D animation proves to be an effective tool for conveying information. This study demonstrates that such an approach can enhance understanding and awareness of marine ecosystems. Therefore, the application of 3D animation is recommended to foster public awareness and emphasize the importance of conserving marine biodiversity.

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