Embodied Cognition and Scientific Game Design: An Innovative Approach to the Conservation of Critically Endangered Waterbirds

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Abstract. Science popularization education is integrating into everyday life, with a growing emphasis on subjectivity and proactiveness. The emphasis on audience experience in science popularization game design aligns perfectly with the concept of‘embodied cognition’, highlighting the crucial role of bodily perception in the cognitive process. This convergence provides a fresh perspective for science popularization. Critically endangered waterbirds represent a significant conservation group, yet their population continues to decline, lacking relevant popular science promotion and design. This study focuses on China's critically endangered waterbirds, integrating and extracting information on their appearance, habits, living environment and survival threats. These elements form the foundational content of a popular science game, where game narratives are designed and integrated with sensory interaction. The aim is to develop and promote a prototype of a popular science game focusing on critically endangered waterbirds, introducing an embodied cognition perspective into popular science game design, thereby providing a broad and engaging exploration for animal conservation and science communication.

1.Introduction

Global biodiversity is facing significant threats. Research indicates that the sixth mass extinction caused by human activities is imminent. Since 1970, the populations of mammals, birds, amphibians, reptiles, and fish have, on average, declined by 69%[1]. The importance of protecting wild populations is reflected in the revised "Law of the People's Republic of China on the Protection of Wildlife" implemented in 2023. Among various animal species, birds are widely distributed and serve as an early warning system for environmental issues, playing a crucial role in the Earth's ecological conditions. According to data from the IUCN Red List, threatened bird species in China are primarily found in coastal areas, making waterbirds valuable for research. Many waterbirds are migratory, with some species covering one-way migration distances exceeding 10,000 km annually. Their seasonal migration activities across national borders make these species an international natural resource.

Popular science is a series of continuously changing processes, practices, and participants that generate and transform public knowledge across time, space, and culture[2]. Currently, scientific elements are integrated into many aspects of life, and popular science work advocates for the creation of ubiquitous popular science spaces, emphasizing participation and interactivity[3]. There is an increased focus on audience participation and experience in popular science work. Embodied cognition is a new development in cognitive science, suggesting that cognitive processes are rooted in the interaction between the body and the world. Embodied cognition mainly refers to the crucial role played by the body in cognitive processes, where human cognition is formed through the body's experiences and activities[4]. The practical application and use of embodied cognition theory align well with the adoption of new technologies. It is widely studied in disciplines such as computer science, education, engineering, design, etc., providing a perspective for popular science design practices that offer users a sensory experience.

According to data from the International Union for Conservation of Nature (IUCN), China is home to 213 species of water birds. Among them, five are classified as "Critically Endangered," namely Baer's Pochard, Spoon-billed Sandpiper, Chinese Crested Tern, Siberian Crane, and White-shouldered Ibis. The populations of these bird species are currently on a declining trend, and conservation efforts need to be taken with a focus on education and awareness. In the promotion and educational outreach, to achieve wider dissemination and audience engagement, considering the entertainment and accessibility of communication, and as a knowledge medium that is both interactive and procedural, electronic games can effectively enhance learning participation and cognitive effects[5]. In this study, the form of educational games is chosen for design research to address the protection of these endangered bird species.

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2.Science game design promotion process

The knowledge content about critically endangered waterfowl is extensive and complex. This study organizes information from a large number of sources, covering the external features, habits, habitat conditions, survival threats, and protective measures related to critically endangered waterfowl. Considering the format of electronic games, we choose science popularization content with visual effects and transform it. Bird postures, living scenarios, threat events, etc., serve as science popularization clues, combined with embodied experiences, gradually unfolding from details to a comprehensive view, immersing users in the survival world of critically endangered waterfowl. The focus of the research is on how to use embodied experiences to enhance user immersion and optimize knowledge dissemination.

2.1. Integration of scientific information on critically endangered waterbirds

In the process of researching existing popular science information on critically endangered waterfowl, relevant data was collected from online browsers. After screening and deduplication, the data revealed 698 records for the Baer's Pochard, 739 records for the Spoon-billed Sandpiper, 721 records for the Chinese Crested Tern, 732 records for the Siberian Crane, and 179 records for the White-shouldered Ibis. Analysis indicates that the information often focuses on the morphological characteristics and distribution areas of these five critically endangered waterfowl. The popular science activities and designs related to the Chinese Crested Tern are particularly rich, including popular science picture books, documentaries, cartoon characters, and more. The Siberian Crane is often associated with positive symbolism. Overall, the content dissemination has a relatively dispersed focus and lacks interactive popular science formats. In response to this issue, this study attempts to address the problem from two aspects.

In the game, we construct the survival environment for critically endangered water birds, integrating relevant knowledge points to depict their coexistence with the natural environment. Building upon the extraction of the external features of critically endangered water birds, we showcase their habitat conditions, allowing the audience to explore the surrounding areas and gain an understanding of the entire ecological environment while learning about these endangered birds. Through organizing and analyzing images and videos of five critically endangered water bird species and obtaining relevant information from BirdLife, we establish the species' characteristics and variations in movement postures, as shown in Figure 1. At the beginning of the game, informative knowledge about critically endangered water birds, including videos and audio, is provided to players. This involves the three-dimensional modeling and animation design of the main subjects, complemented by the recognition of real images corresponding to bird species to enhance impressions. Based on the established survival environment, a corresponding virtual three-dimensional space is created, including ponds, wetlands, beaches, etc. On this basis, specific areas are designed with hidden elements, encompassing aquatic vegetation, terrestrial insects, and fish related to their living habits, as well as threats they face, such as human intrusion and disturbance, wastewater pollution, and threats from other species. This approach enriches the game's constructed survival environment, aiming to realistically portray the survival status of critically endangered water birds as much as possible.

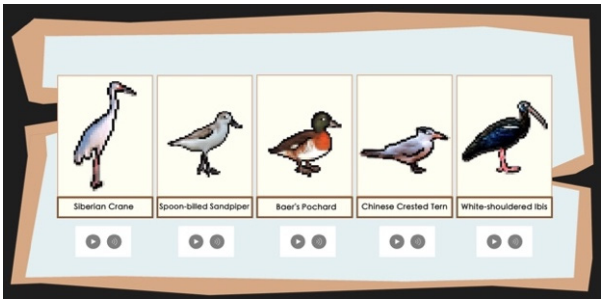

Fig. 1. Illustration of game waterbirds selection.

The construction of the game map is implemented to connect the habitat environments of critically endangered waterbirds in the form of a map background. Critically endangered waterbirds migrate across a large geographical range. After players choose a waterbird, they form impressions of the corresponding survival environment. This approach makes the geographical location and movement patterns of the critically endangered waterbird more intuitive, showcasing distribution areas on a larger scale and enhancing the comprehensiveness of popular science information retrieval. Initially, the directory of the game map primarily relied on text design for the main differentiation of regions. However, through experimentation, it was discovered that due to significant differences between regions and the more visually intuitive nature of image information, the final design adopted distinctive environmental features as the main differentiating points between regions. Rapid browsing of the directory is achieved through left and right swiping.

2.2.Embodiment experience in science popularization approaches

The design of popular science games not only focuses on visual and content information but also emphasizes interactive experiences. In contrast to the commonly used text and image presentation format in current popular science communication, this study incorporates the theory of embodied cognition in its design to enhance the audience's embodied experiences and deepen the impression of popular science knowledge. Embodied cognition can be understood from three perspectives, corresponding to the design of popular science games.

Firstly, due to the influence of physical attributes on cognitive formation, the game guides the audience to simulate the movement patterns of critically endangered water birds from the perspective of such birds. It emphasizes how critically endangered water birds utilize their physical attributes to survive in aquatic environments. Through player-experiential interactions, emotional

engagement is enhanced. Secondly, embodied cognition posits that cognitive content is provided by the body. In the game design, a popular science approach based on bodily experiences allows the audience to feel the survival challenges of critically endangered water birds. It underscores the similarities between critically endangered water birds and the human somatosensory system. The choice of integrating their calls with environmental sounds from nature aims to engage the audience's visual and auditory perceptions. Thirdly, embodied cognition further asserts that cognition is embodied, and the body is embedded in the environment. The game incorporates interactions between the subject of critically endangered water birds and hidden factors. It provides opportunities for the audience to interact with the living environment of critically endangered water birds, such as flying, foraging, and avoiding traps. This enables the audience to better understand and experience the dynamic balance between species and habitat. Some survival threats are attributed to human behavior, and such interactions in the game help players comprehend the impact of human actions on ecosystems. While acquiring educational knowledge, players deepen their awareness of animal conservation.

2.3.Establishment of popular science game solutions

As a science popularization game design that values embodied experiences, the survival story and design concept unfolding from the perspective of critically endangered waterfowl align well. Combining scientific knowledge content with embodied experiential forms, the game objectives are established such that players, through completing tasks and engaging in protective actions, enhance the health index of the habitat for critically endangered waterfowl. The player's actions directly impact the happiness index of these waterfowl, ensuring the reproduction and survival of the species population.

The design of the game story is divided into five segments: Incubation and Growth, Threat Discovery, Interaction and Missions, Exploration of New Territories, and Protection Decision. In terms of specific story design, players initially experience the hatching and growth process of critically endangered waterfowl from eggs, gaining insights into the birth of this group of beings. As they grow, players will experience various special abilities of waterfowl, such as flying, foraging, and establishing a habitat. Within the game, players will discover threats in the wetlands, including those arising from residential and commercial development, agriculture, aquaculture, energy production, and extraction. The central theme of critically endangered waterfowl will directly undergo environmental changes, sensing the harm posed by threats to their habitat. Players can undertake a series of tasks, such as collecting food, building nests, and guiding the migration of small waterfowl flocks. During these tasks, waterfowl will face challenges such as obstacles in traffic channels and harvesting of biological resources, requiring players to cleverly utilize the abilities of critically endangered waterfowl to overcome them. By completing tasks, players will have the opportunity to unlock new territories on the map, including other wetlands, beaches, lakes, etc. Each new territory has unique ecosystems and challenges, providing players with more adventurous experiences. At the same time, players must make protective decisions, including choosing suitable migration routes, participating in environmental activities, and seeking secure habitats. These decisions will directly impact the safety and stability of the habitat of critically endangered waterfowl.

3.Optimization design of popular science game for critically endangered waterbirds

The game plan has been established, in the concrete process of game design and implementation, considerations are made about the degree of implementation and entertainment of the game. Optimization of the design takes into account the difficulty level and evaluation system of the educational game, as well as interactive forms that can be widely implemented.

Optimizing the game flow, as illustrated in Figure 2. Before embarking on the gaming expedition, players gain a general understanding of waterfowl information based on the critically endangered waterfowl field guide. This step encompasses the provision of bird calls and video introductions. Players choose a specific waterfowl species, and for this critically endangered waterfowl species, they select the corresponding activity area to initiate the game. Within the game, players encounter two types of tasks: routine tasks and hidden tasks. Upon the conclusion of a gaming session, the tasks completed by the player are recorded in the achievement system. Based on the scores within the achievement system, players can make informed conservation decisions and implement them in the subsequent gaming session.

3.1. Improving game difficulty and achievement system

Establishing the narrative content of the educational game, we plan and design the difficulty levels and achievement systems. Within the game, we introduce diverse difficulty challenges to push players to their limits, fostering sustained engagement. Completion of tasks results in unlocking rare rewards. Additionally, the game dynamically shifts the player's perspective during the gameplay, enhancing experiential variety, and introducing memory points aligned with the timeline.

In the gaming setting, enhancing the physical attributes and behavioral characteristics of critically endangered waterbirds divides the game into different difficulty levels. Completing routine tasks and hidden missions with the bird's beak and wings contributes to the classification of difficulty levels. Additionally, based on the diverse geographical features of habitats and the threats faced, game levels of varying difficulty are designed. Foraging and flying, representing fundamental survival skills, make task completion relatively straightforward. Discovering interference from other species, and building nests, requiring more collaboration and observation, presents a

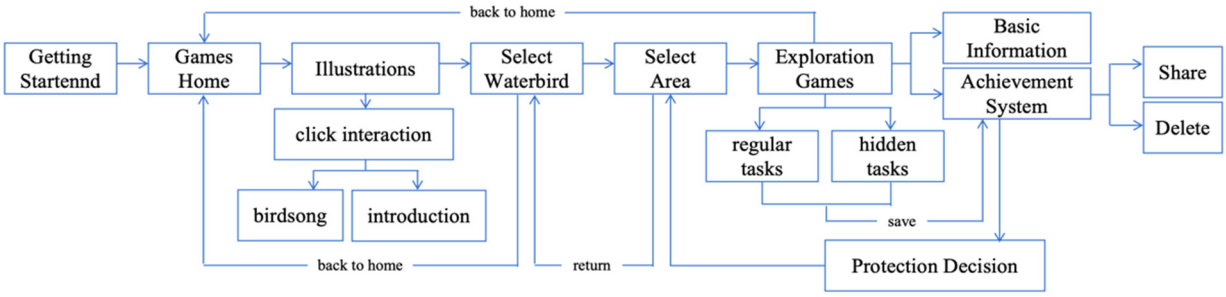

Fig. 2. Game process design.

moderate level of difficulty. Avoiding water pollution, human intrusion and disturbance, and selecting appropriate migration routes necessitate comprehensive considerations, posing the highest level of task difficulty.

Following this, an achievement system was designed based on game progress and mission difficulty to enhance the experience of real-time feedback in the game. As the player completes an increasing number of tasks, the system assesses corresponding achievements for the health index of the habitat for highly endangered waterfowl. During the game, achieving five hidden tasks, including marking trapping traps, marking garbage pollution, and solid waste pollution, will unlock a rare achievement for the player. In the map directory section, the number of regional tasks and hidden tasks is added, providing choices for conservation decisions. By selectively making conservation decisions and implementing them in subsequent gameplay, players can obtain conservation achievements.

3.2.. Exploration of interaction forms in popular science games

To enhance the accessibility of popular science dissemination and the operability of the game, the endangered waterfowl popular science game in this study is implemented on smartphones. The interface design incorporates features such as perspective switching, return to map directory, target task system, and prompt icons, facilitating players to switch between different interfaces.

In the selection of interactive forms, the choice is made to utilize a sliding touchscreen to control the camera perspective of critically endangered waterfowl subjects. The movement of a slider is employed to control the subjects' actions, and clicking on the environmental scenes facilitates task selection and execution. This approach is employed to realize the fundamental functionalities of an educational game focused on critically endangered waterfowl. Experimental results indicate that the sliding touchscreen control has a limited display range for the perspective. To address this, the operation is adjusted to a double-tap method for changing the field of view, providing players with a more realistic experience. This simulation allows for different perspectives of land and sky, facilitating the observation of the impacts of conservation decisions and the migratory paths of critically endangered waterfowl subjects. The synchronization of the smartphone screen with the player's perspective creates an embodied experience, allowing a more vivid understanding of the lifestyle of critically endangered waterfowl.

4.Conclusion

Popular science game design is a complex process, and the integration of embodied cognition theory offers a new perspective for popular science game design. Through interactive means, the design aims to assist the audience in subtly acquiring popular science knowledge. This approach, using games as a medium, conducts animal conservation advocacy in a natural and engaging form, with the expectation of stimulating players' curiosity and learning interests. Embodied cognition theory introduces a fresh perspective for game design. This design not only serves as an innovative exploration in popular science communication research but also adds an element of fun to the dissemination of knowledge.

References

1 Almond, R.E.A., Grooten, M., Juffe Bignoli, D. & Petersen, T. (eds). Living Planet Report 2022 – Building a nature-positive society (WWF, 2022).

2 Daum A W. Varieties of popular science and the transformations of public knowledge: some historical reflections[J]. Isis, 2009, 100(2): 319-332.

3 Han Xuebing, Yang Hua, Zhou Xinchi, et al. Research on Network Interactive Popularization Science Mode of Mass Audience [J]. Journal of Modern Information,2013,33(10):149-152.

4 Ye Haosheng. Embodied Cognition: A New Approach in Cognitive Psychology[J]. Advances in Psychological Science, 2010,18(05):705-710.

5 Chen Peng. Research on the New Pattern of Science Communication in the New Media Environment—also on the Development Strategy of China Science Journal[D]. Hefei: University of Science and Technology of China, 2012.