Designing a Serious Game Utilizing Beaver Behavior for Water Responsibility Education and Communication

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Abstract

This paper introduces an approach to water responsibility education and communication through the design of a serious game centered around the behaviors of beavers. With a growing global concern for water conservation and responsible usage, innovative methods are necessary to engage and educate diverse audiences. Building upon traditional ecological knowledge and leveraging the captivating characteristics of beavers as ecosystem engineers, this research delves into the development of an interactive game aimed at fostering a deeper understanding of water conservation practices. The game design integrates key aspects of beaver behavior, such as dam construction and habitat management, to simulate real-world scenarios related to water resource and landscape management. By gamifying these concepts, the aim is to promote awareness, inspire responsible water usage, and facilitate meaningful conversations about conservation practices among players. Drawing upon principles of traditional ecological knowledge, education and game design, this study outlines the theoretical framework behind the game's development. Additionally, the paper discusses the design process, highlighting the challenges, considerations, and strategies employed to create an immersive and educational gaming experience.

Keywords

immersive environments, 3D worlds, traditional ecological knowledge

Introduction

Interactive media environments provide a space for connection with other participants in collaborative activities, creating a sense of being part of a larger social structure [34, 12]. The experiential aspect of interactive media highlights the transformative capacity of creative spaces of inquiry. As an experiential learning environment, interactive media facilitates a space for ontological reflexivity'[6]. This approach enables the process of integrating alternative ways of knowing through multisensory experience and activates lateral thinking as well as an intuitive grasp of concepts: "Experiential knowing equally offers all the possibilities to see and understand the world and ourselves within that world in polyphonic, symbolic, artful and imaginative ways" [7].

Interactive media that combine process-driven modeling and visualizations provide a valuable format and tool for introducing sustainability practices. Galanter [13] argues that interactive media is uniquely positioned to open a common space across the sciences and humanities. This type of dialogical space is an essential resource for addressing sustainability. Just as interactive media is complex, sustainability is a complex problem[15, 24], with many interconnecting and often competing facets that need to be understood from multiple, interdisciplinary perspectives [23, 8]. Sustainability is thus a perfect theme for a "serious game", which is a form of interactive media designed for a primary purpose other than entertainment. Serious games can create experiential learning environments that represent the complexity and fluidity of a problem as well as open up spaces for dialogue (dos Santos et al. 2019). Serious games and simulation in sustainability education have proliferated over the years, focusing on the themes of energy, climate change, and natural resource management [31, 14, 9].

Researchers recommend addressing the complexity of climate change and sustainability issues by visualizing concepts and making them locally relevant and concrete, grounded in experiential learning, and situated in interactive media environments [21, 11, 27, 2, 25]. Using 3D visualizations can convey strong messages quickly, condense complex information, engage viewers, and motivate personal action on climate change [19, 25]. These visualizations can trigger innate reflexes and feelings and generate lasting emotional responses [29, 36]. Evaluations of visualizations have shown that their higher realism leads to more emotional and/or more relevant responses, and interactivity can improve cognition [28].

In this paper, we discuss our interactive media design toward communicating the critical condition of Okanagan water reserves, and the importance of interspecies collaboration with beavers. The research aims at narrowing this cross-cultural gap in water sustainability through the design of a 3D serious game to provide an imaginative space of engagement and reflection on multiple realities embedded in the Okanagan in terms of geopolitical issues, species, futures, water availability, conflicts, demographics, biodiversity, and beauty. In an attempt to address these goals, this paper explores the design process of an interactive game that adopts a cross-cultural perspective, incorporating Indigenous values on water and reflecting ecological knowledge. It creates a digital space where the players embody a beaver to learn about its significance as a wise creator, restoring water paths, and rejuvenating ecosystems that may be otherwise lifeless. We align

our process with Indigenous methodologies that form a holistic research paradigm, which expresses realities as relational and interconnected [3, 16, 26, 33]. Indigenous approaches to research are conducted through relational accountability, which means that responsibility, relevance, as well as respect for and reciprocal engagement with all living beings are considered [33]. Reciprocal engagement requires researchers to co-develop, exchange, and participate in the local community context [30], highlighting collaborative processes for constructing knowledge through self-reflexive engagement and participatory action. These ideas provide a research context for designing the proposed 3D game and environments that bridge intercultural and interdisciplinary ways of knowing to benefit all the involved partners.

Background and Context

Located in the territories of the Syilx Okanagan people, the Okanagan watershed is an 800 square kilometer water basin that feeds six lakes in the province of British Columbia. The Okanagan region is classified as semi-arid [5], with over 80% of the valley's average annual rainfall lost to evaporation [20], making it Canada's most water-challenged area, with the lowest per-person water availability compared to any other region in the country. Despite these water conditions, domestic per capita water use in the Okanagan is more than twice the national average [20]. Given current water usage patterns and projected population growth, the valley will face significant and persistent water shortages by mid-century [20, 4]. While longer, drier summers and more frequent droughts have become the 'new normal' in the Okanagan (OBWB 2011, Neilson et al. 2018), a pervasive 'myth of water abundance' persists among many Okanagan residents, impeding public understanding of the gravity of the situation [32] and the required mitigative actions. This public inertia cannot be blamed on the inaccessibility of information as water sustainability has been the subject of extensive research and awareness-raising in the Okanagan, particularly since the early 1970s with the creation of OBWB. Rather, inaction on issues such as climate change is more likely related to the lack of perceived relevance at the local and personal level as well as cultural and social norms [17, 18].

For the Syilx people, water is viewed as a resource not owned but borrowed and it has to be well taken care of to be passed to future generations. The term siwɬkʷ (water) provides a key understanding of Syilx perspectives. It combines how humans drink (like from cupped hands) and the sounds animals make when drinking. This term embodies the concept that both humans and animals share an equal entitlement to water. To preserve the paths of water and its inherent nature as a sustainer of life, the Syilx Okanagan Nation has adopted its Water Declaration [1]. This document articulates the centrality of water and the Syilx people's responsibilities to always manage water sustainably and respectfully. Another critical part of this document is that it identifies mountain beavers as an ally in restoring dried wetlands and water ecosystems. The underestimated value of the beaver could be an essential asset in mitigating the drought and wildfires experienced in the area.

Throughout history, Syilx Okanagan People heavily depended on beavers for maintaining water paths and wetlands. Mountain beavers, for instance, constructed dams in high mountains, creating wetlands, ponds, and lakes that served as filters for siwɬkʷ. These wetlands are crucial habitats for local vulnerable species, acting as off-channel rearing areas and a food source [1]. Beavers, inhabiting the land-water intersection, consume wetland plants and bark from riparian trees. Their daily activities inadvertently create opportunities for the other species to thrive. Employing fallen sticks, they construct dams in streams and small channels, altering water flow. These dams elevate stream levels, forming deep ponds that house diverse species, including birds, salmon, and amphibians. Adjacent land is flooded, promoting the growth of new willows. A landscape shaped by beavers is markedly different, as they engineer dynamic habitats through transformational processes, reminiscent of human engineers' works [35].

The significance of beaver constructions for water ecosystems is not only recognized by traditional Indigenous knowledge but is also affirmed and supported by conventional scientific literature. In the early 2000s, environmental scientists explored the possibility of human collaboration with beavers to restore deteriorated streams. In Bridge Creek in Oregon, Michael Pollock and his colleagues placed fence posts in the streambed below a beaver dam that was damaged by floodwaters and created a structure for the beavers to build on top of [22]. The collaborative dam, reinforced by beavers, effectively resisted floodwaters, elevated water tables, and attracted frogs, trees, and salmon. This experiment gained attention, marking the start of a "beaver movement" led by passionate "beaver believers" advocating for these ecosystem engineers [35].

Methodology

To explore the use of a place-based game as a potential solution to water security in the context of climate change, we utilized a transdisciplinary approach building on climate change communications, landscape visualization, educational games, and co-design. For this project, we determined the target audiences are primarily non-expert local community members representing three user groups:

- Youth (high school students, teenagers, and college-age adults, reached for example, through schools, museums, and community centers), since these are traditionally hard-to-reach audiences;
- Their parents (reached through their children and community events), as representatives of general citizens who may be more inclined to play games due to their children's influence; and
- Policy-makers (such as council members, committee members and appointed advisory boards), who determine key responses within their realm of governance, and who need to stay in close touch with their constituents.

Despite the diversity of the target audience, they all share a common focal point: the land. This approach underscores the significance of local attachment by utilizing place and

Figure 1: Screenshot of game depicting a player's beaver character situated in a meadow environment. © of the authors

community-based strategies to enhance salience, align with cultural context, community identity, personal issues, and elicit affective responses. Drawing on the previous literature, we identified the following characteristics of successful games in engaging youth and others on water responsibility in the context of climate change, to guide the design process:

- The role of visual media and realistic or semi-realistic landscape visualization (in combination with other media) to enhance experiential learning and appeal;
- The need to provide user control over content and navigation, immersing the user in a virtual reality game setting and maintaining interest through game dynamics and real-time feedback;
- Multi-user collaboration in achieving rewards or incentives, allowing shared goal attainment, and taking advantage of peer pressure;
- Transparency in revealing the sources of scientific information to build credibility.

With respect to the design goals mentioned above, the game is planned as a multiplayer survival game where the players work together to survive harsh environmental conditions. The game allows the participants to embody a beaver, which is native to the Okanagan. In this role, players engage in collaborative efforts with each other to overcome environmental challenges and rejuvenate wetland ecosystems and creeks through the construction of dams and beaver lodges. Within the gameplay, participants gain insight into the environmental consequences of their actions, observing how structures, such as dams, influence water levels, promote plant growth, and facilitate the return of Salmon species. Moreover, players become acquainted with local flora, enhancing their understanding of the significance and practical applications of these plants. The gameplay is structured in a cyclical manner, devoid of a definitive endpoint. As the seasons unfold, players embark on a continuous quest for survival, and their achievements are gauged by the duration they can endure and sustain the dynamic environment. The accomplishment of players is linked to their ability to navigate the evolving landscape, ensuring the longevity of their survival efforts. This approach not only immerses players in a continuous and evolving experience but also underscores the importance of adaptability and resilience in the face of the dynamic challenges presented by the game's environment.

Development

For this game, creating a flexible and interactive environment that accurately reflected the Okanagan was essential. As the beavers collaborate to survive the winter and wildfires and make the environment more resilient through their structures, this environment would be the key tool for illustrating the beavers' impact on the landscape. To implement the landscape visualization, we have built upon the resources of the 'Waterways' project [10], which developed place-based 3D landscape assets for imagining the Okanagan before colonization and visualizing the creeks and rivers that have dried up due to industrialization. To ensure an accurate representation of the Valley, we utilized Global Information System (GIS) technologies and obtained a topology map to serve as the game terrain.

The plants in the game accurately mirrored the real landscape. As a result of participatory design and action endeavors, the plant library took a few years to develop, involving the efforts of students and scientists from diverse backgrounds. The 3D textures of the plants were generated using photos taken by participants during field trips. Information about the plants was collected from Indigenous Knowledge Keepers, elders, scientists, and academicians. All the 3D plants and their related knowledge were compiled in a library to serve as an asset for both the Waterways project and future endeavors.

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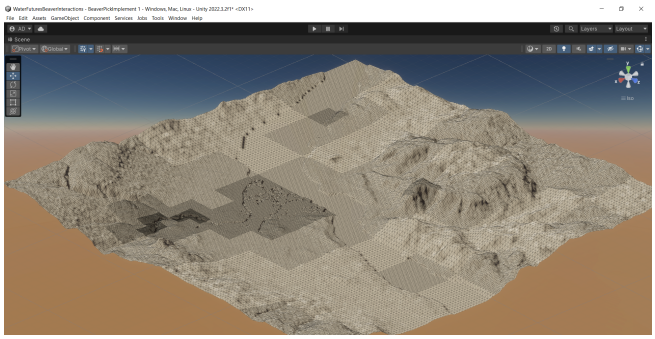

Figure 2: An image of the Okanagan Basin terrain map. © of the authors

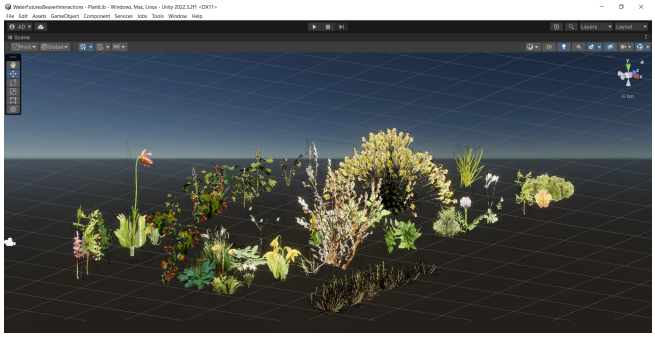

Figure 3: A screenshot depicting a range of local Okanagan plant species used in the game environment. © of the authors.

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In the game environment, players have the option to engage with the flora as they explore the landscape. If they choose to interact, informative pop-ups appear, providing text that delves into the significance of the plant. This information encompasses both scientific perspectives and insights from traditional Indigenous knowledge. It includes details about the plant's importance, its historical context, and any stories or elements of cultural significance associated with it. To ensure the credibility of the information and acknowledge the real Indigenous Knowledge Keepers, we have invested considerable effort in citation and transparency when presenting this data. Every piece of information is carefully sourced, providing players with a reliable and authentic understanding of the plants within the game environment. This approach not only enriches the gaming experience by offering educational insights but also emphasizes the respect and recognition of Indigenous knowledge throughout the gameplay.

To fully immerse players in the digital recreation of the Okanagan, it was crucial to grant them complete autonomy

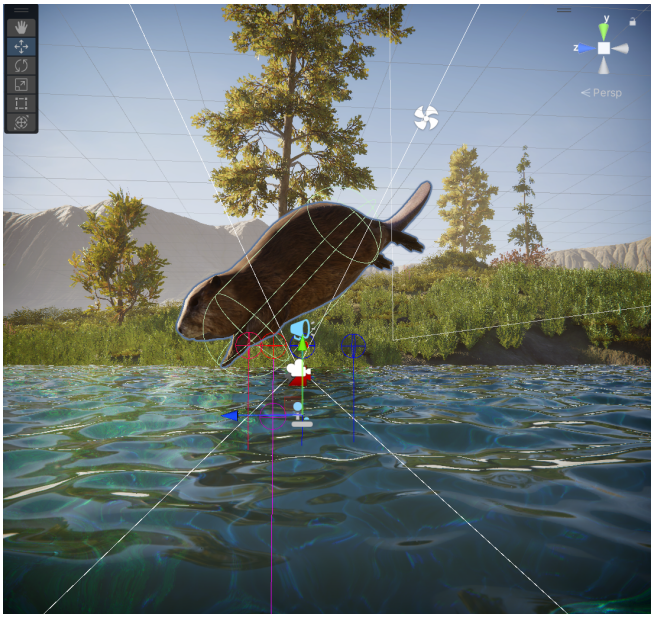

Figure 4: An image of a beaver character in a mid-air pose in the process of jumping. © of the authors.

and control over their characters. This freedom allowed players to explore, navigate, and be present within the digital landscape, fostering sustained engagement with the game. To authentically embody the beaver experience, we designed the interactions to faithfully replicate real-world beaver actions. This meant players not only had the freedom to explore, run, and interact with nature, but they also had the capabilities to perform essential beaver activities such as eating, sleeping, building, swimming, running, and even facing the prospect of mortality – mirroring the day-to-day life of a beaver.

Ensuring that the interactions within the game aligned well with the learning objectives and acted as a motivating force for continued exploration was crucial. This game was conceived as a simulation, aiming to visualize not just the pre-contact Okanagan but also the profound impact of beavers on the natural environment. As the beaver engages with the surroundings and constructs structures, the game's design mirrors these alterations. Constructing a dam, for example, has multifaceted effects—it can raise water levels, creating depth that facilitates water infiltration into the ground. This, in turn, benefits nearby plants, promoting their growth and nourishment. The landscape, enriched with more moisture, gains resilience against wildfires. Furthermore, the deepened water creates colder conditions, fostering an optimal environment for salmon, fish, and other amphibians to reproduce and thrive. The significance of beavers goes beyond landscape alterations; the creation of beaver lodges is a critical survival strategy. During the harsh winter, with temperatures plummeting as low as minus 20 degrees, beavers require shelter. Inhabiting a Beaver Lodge proves to be optimal, offering warmth with interior temperatures as high as 12 degrees during the cold winter months.

Building upon this ecological knowledge, our aim was to

Figure 5: A screenshot of a beaver in a field. © of the authors

Figure 6: A screenshot of a beaver swimming in a body of water. © of the authors

highlight the importance of interspecies interactions as the primary learning goal. The game's incentive lies in the collaboration needed to navigate the challenges, especially in the face of harsh weather conditions. To survive, players must construct dams, build shelters, and ensure sustenance for themselves and their colony. This deliberate design approach fosters collaboration among players, allowing all to thrive and learn collectively.

To foster multiplayer collaboration, we made deliberate design choices that deviate from conventional survival games. One distinctive choice was the absence of a traditional inventory system. While many similar games rely on salvaging and stockpiling materials within an inventory, our game takes a different approach. Anything a player collects is visibly shown on their avatar, and there are constraints on the amount they can collect. For example, a player can only gather up to 10 sticks, and each collection comes with an energy. To regain energy, players must find and consume food. However, if a player is holding sticks and encounters nearby food, they can't eat it unless they drop the sticks. Picking up the dropped items again incurs an additional energy cost. This design encourages players to collaborate rather than hoard resources, promoting teamwork and shared efforts.

This intentional limitation prompts players to consider their choices strategically. Instead of a solo player accumulating all the sticks, potentially hindering the progress of the team, players are motivated to share resources. If a player's energy is low, others can contribute by bringing food to them while they continue with their assigned tasks. This collaborative approach encourages teamwork and enhances the overall gaming experience, emphasizing the interdependence of players to achieve common objectives.

Discussion and Conclusions

By adopting a cross-cultural perspective that incorporates Indigenous Syilx values on water and reflects traditional ecological knowledge, the game aims to bridge the gap in understanding and commitment to water conservation. The historical reliance of the Syilx Okanagan People on the beavers for maintaining water paths and wetlands underscores the cultural significance of these animals. The collaboration between humans and beavers in shaping the landscape and fostering biodiversity is not only supported by traditional Indigenous knowledge but also finds resonance in contemporary environmental science. The inclusion of beavers as allies in water restoration highlights the underestimated value of these creatures in mitigating droughts and wildfires.

The use of interactive media, specifically a serious game, provides a powerful tool for communicating complex issues related to water sustainability and climate change. The incorporation of realistic landscape visualizations, multi-user collaboration, and transparency in scientific information sources enhances the experiential learning aspect of the game. The game's immersive environment, coupled with real-time feedback, aims to trigger emotional responses and motivate personal action on climate change. The transdisciplinary approach, drawing on theories in climate change communication, landscape visualization, educational games, and co-design, ensures that the game is tailored to diverse audiences, including youth, parents, and policy-makers.

In conclusion, the design of the 3D serious game represents a significant step towards fostering a deeper understanding and appreciation for water sustainability in the Okanagan. By integrating Indigenous perspectives, ecological knowledge, and the collaborative role of beavers, the game serves as a

platform for cross-cultural engagement and education. The emphasis on multiplayer collaboration, realistic landscape visualizations, and the incorporation of credible scientific and Indigenous knowledge sources contribute to the game's effectiveness in conveying complex concepts related to water conservation.

Moving forward, the implementation of the game in educational settings, community events, and policy-making discussions holds the potential to create a meaningful impact on diverse audiences. The ongoing collaboration with local communities and Indigenous Knowledge Keepers ensures the authenticity and relevance of the game. The cyclical nature of the gameplay, devoid of a definitive endpoint, encourages continuous exploration, adaptability, and resilience—key qualities needed in addressing the dynamic challenges posed by climate change.

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We acknowledge that this work is located on the unceeded territory of the Syilx Okanagan people in what is now called Kelowna in British Columbia Canada. The Sylix people have lived and cared for this land for thousands of years and continue to be stewards of this place. We feel that there is much to learn from their world view and offer assistance to make a better future for all living things.

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Miles Thorogood is an assistant professor of digital art in the Faculty of Creative and Critical Studies and heads the Sonic Production Intelligence Research and Applications Lab at The University of British Columbia. His current research aims to identify the facets of human perception used in creative processes to develop computational-assisted tools for art and design making.

Aleksandra Dulic is an artist-scholar with expertise in interactive art, climate change communication, and media for social change. She is the Director of the Centre for Culture and Technology (CCT) at The University of British Columbia. She leads an interdisciplinary research team that engages multiple forms of art, media and information technologies as vehicles for the expression of community, culture, and identity.