Designing CanoeView: A Canoe-Based Interactive Learning Experience for Planetarium Classrooms

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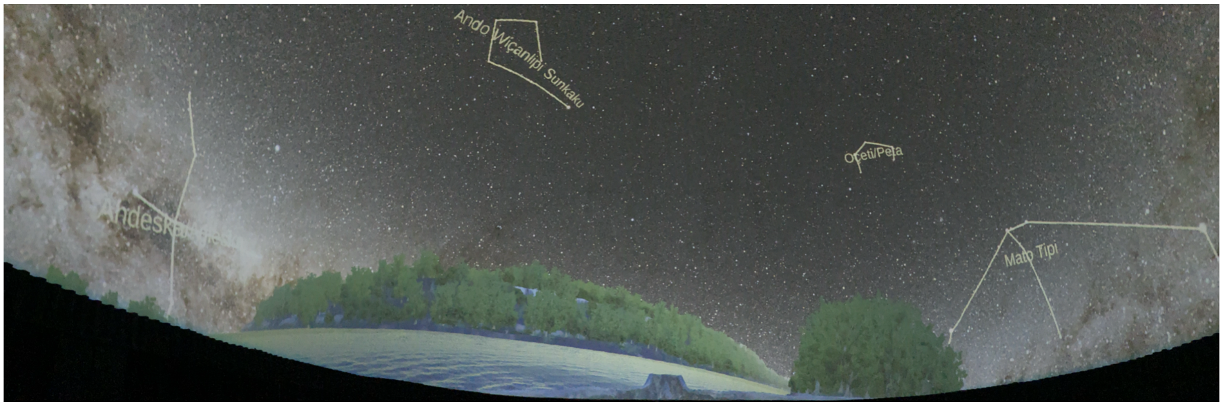

Figure 1: Running CanoeView on a planetarium dome display shows Dakota constellations and the Milky Way. To the Dakota peoples, the Milky Way is known as the Spirit Road, which is where their ancestors originate.

Index Terms: Indigenous Presence, education, display ecologies, input aggregation, group interactions.

1 Introduction

Large-format immersive and semi-immersive data visualizations provide valuable opportunities for engaging interactive storytelling. In planetariums, there is a tradition of live narration that intentionally contrasts with pre-recorded movies. Current teaching and learning in planetariums embraces this model, for example, via interactive storytelling and questions posed to audience members, and there is clear interest and potential to do more. Inspired by recent work on "display ecologies" [4] for visualization, which is an environment where multiple displays can work together, and large scale audience participation methods as described in Maynes-Aminzade et al [6], one thread of our research seeks to understand how students might employ personal tablet devices to further teaching and learning objectives in these interactive visualization spaces.

Our project is also situated within the context of a long-term collaboration between the Interactive Visualization Lab (IV/LAB) at the University of Minnesota–Twin Cities and co-authors Sarah Weaver and Jim Rock. Ms. Weaver is a teacher in the St. Paul School District and runs the Como Planetarium, while Mr. Rock is a Dakota elder and ethnoastronomer; both have been collaborating to create a curriculum that brings Dakota stories into the planetarium classroom. One of many lessons from Mr. Rock that utilizes the affordances of planetarium scale immersion is the Dakota creation story. As described in figure 1, the ancestors of the Dakota peoples followed the Spirit Road down to Earth, arriving at the Bdote, also known as the confluence of the Minnesota and Mississippi rivers. The stars and their relation to the Earth are deeply important to this story, necessitating the use of software that enables Mr. Rock to recount this story in a way that feels intuitive in a planetarium environment. Our goal is to provide Ms. Weaver and Mr. Rock with the necessary tools to support their collaboration, which is not supported by Ms. Weaver's current planetarium software.

In light of our research interests and the needs of our collaborators, we present CanoeView, a data visualization that situates the stars in the local environment of Bdote and enables students' participation in the data visualization through a real-time interaction. Specifically, we contribute a case study and discussion of co-designing an interactive immersive visualization with: a) a star model that includes Dakota constellations and an immersive environment to contextualize them, and b) a canoe paddling-based group interaction for exploring the star dataset. We believe that these will ultimately enhance learning outcomes and increase opportunities for collaboration with Dakota storytellers.

2 Related Works

Our project is guided by the Five Factors for activating Indigenous Presence presented in Dorr et al.'s [5] recent report on working with Indigenous communities. At this current stage, our work is most closely tied to factor three, creating culturally identifiable experiences. Yu et al. [8] suggest that visual immersion, achieved through the use of a full dome, has benefits for learning as it reduces some cognitive load. Maynes-Aminzade et al [6] describes crowd interaction techniques for the purpose of entertainment. We aim to create an immersive environment with crowd interactions with the student, which we reason has the potential to enhance learning outcomes. There are some examples of planetarium software created for similar purposes [3], and it may be possible to implement the

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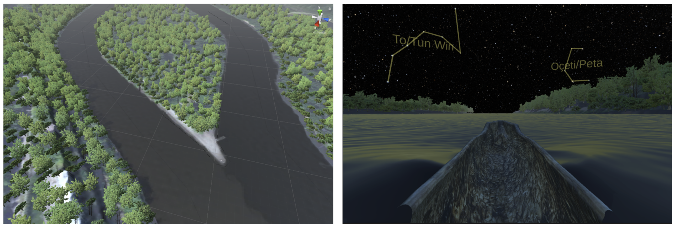

Figure 2: Screenshots of CanoeView running in Unity. CanoeView is situated on and around the Bdote [left], which is the confluence of the Minnesota and Mississippi river. This, in combination Dakota constellations [right], creates an appropriate context for Dakota storytelling.

features described in this paper as plugins for some of them.

3 CanoeView

CanoeView uses a terrain and celestial model in concert with asymmetric displays to create a display ecology for collaborative storytelling, in which we currently have three different sets of displays. First, the planetarium dome, used as a collaborative display where all users can see the star data together. Second, student devices that act as distributed control interfaces, which are secondary displays that enable students to navigate the canoe through the environment. Finally, the teacher also has a distributed control interface which is used to control parameters such as the speed of the canoe, time of day, and visibility of constellations.

3.1 Celestial Model and Dakota Constellations

CanoeView uses a model of the stars that is based on the concept of a celestial sphere and a C# implementation of portions of Astronomical Algorithms, specifically the calculation of the position and rotation of the sphere using the sidereal time, latitude, and longitude [7]. We converted images of the Milky Way and bright stars from NASA [2] into cube maps, blending them to render onscreen. In order to facilitate Dakota storytelling, Dakota constellations are a necessary part of the celestial model. Constellations are customized in a text file using Yale Bright Star Catalog numbers and rendered on the celestial sphere using celestial coordinates from the catalog.

3.2 Bdote Terrain Model

The objective of CanoeView is to immerse Dakota storytellers in an environment that enables them to navigate the star data in a way that feels intuitive, making realism a key priority. As seen in figure 2, the visualization is located around the Bdote and gives the students a view from inside the canoe. The terrain model around the canoe is based on a 1m resolution dataset from the Minnesota Geospatial Commons [1] which is converted into a Unity terrain object using the Real World Terrain plugin. Trees were added to the terrain by hand.

3.3 Canoe Paddling Group Interaction

The goal of this interaction is to determine where the students, as a group, want to guide the canoe in real time. To do this, we use input aggregation: distilling many individual inputs into a single on-screen action. Based on these design objectives, we designed a system that has students connect to a server from their personal electronic devices through a website. Students connect to a server via a website on their personal devices and choose either "left paddle" or "right paddle." Once all inputs are received, the server selects the majority choice and reflects it on screen. This system uses a C# WebSocket server hosted in Unity.

4 Future Work and Conclusion

The student display provides an interesting avenue for investigating possible collaborative interactions for display ecologies. Chung et al. [4] mention, "Collaborative analysis results often represent a combination of both individual and collaborative efforts." Thus, we aim to research interactions on the student display that fall into two categories: a) interactions done together, collaboratively, and b) interactions done individually and then shared with the group. When combined with principles of designing audience interactions outlined in Maynes-Aminzade et al [6], particularly interactions that are grounded in the real world, have obvious control mechanisms, and facilitate cooperation between the students, these interactions could foster a collaborative display ecology. The canoe paddling group interaction falls into the first category, but more work needs to be done to bring it in line with the audience interaction design principles mentioned above. Students could instead move their devices in a way that is analogous to actual canoe paddling, helping ground the interaction in the real world. We have yet to implement interactions in the second category, but examples include enabling students to draw pictures of constellations on their personal devices and sharing them with the group on the planetarium screen, or "digital puppetry", where students can use their personal devices to animate their drawings on the main screen to underscore the Dakota storyteller's presentation.

While there are several system building tasks that are also next in our future work, we are excited to continue researching immersive, collaborative storytelling experiences for students and Dakota storytellers. We believe these contributions have potential to enhance learning outcomes and further increase collaborations between planetarium educators and Dakota storytellers.

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