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

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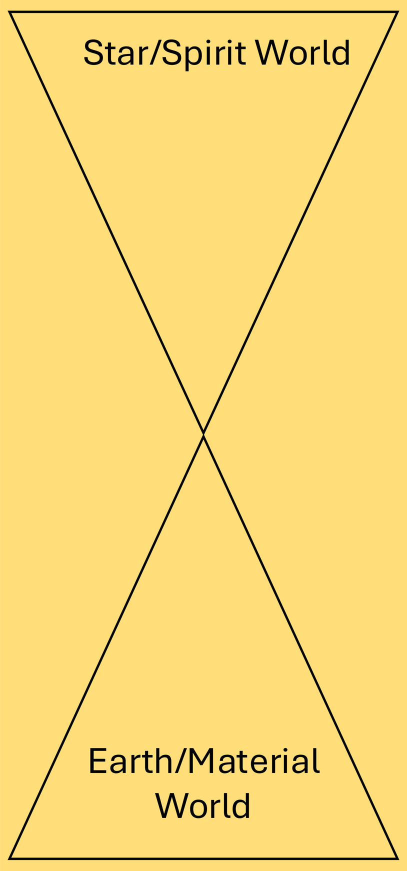
Introduction

Current data visualization technologies do not support Dakota storytelling



A kapemni figure

For the Dakota peoples, storytelling is a powerful method often deployed in intergenerational environments. The concept of **Kapemni**, which is what happens above in the sky is mirrored here on Earth, is frequently used to orient learners conceptually. Creating the proper environmental context is important for this type of teaching and learning to occur.

CanoeView running on the Como Planetarium dome

Our Work Asks:

How can we utilize mobile technologies in conjunction with planetarium dome projections to enable Dakota storytelling?

How might this combination improve learning experiences for all planetarium learners, including both Dakota and non-Dakota peoples?

Planetarium displays provide new opportunities to support Dakota teaching

Given the natural orientation to the sky and immersive affordances, planetariums provide opportunities for Dakota teachers to deploy storytelling more naturally. While traditional teaching in K-12 planetarium environments focuses on the sky, Dakota storytelling requires attention to land happenings as well. To facilitate this connection, we a). Combine a 3D visualization of the land with the sky and b). utilize mobile tablets as an interactive input device for navigating these data sets, thereby contextualizing sky lessons that are rendered in planetarium dome environments.

Guiding Literature and Approaches

Our research centers on Indigenous Presence

To ensure our work is of service to Dakota communities, we follow 5 Factors for Activating Indigenous Presence [5] to guide our work:

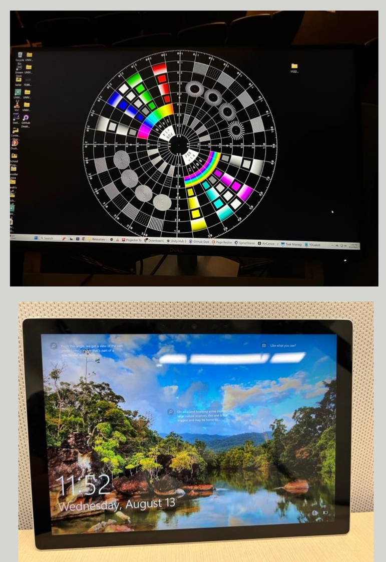
1	2	3	4	5
Having a community relevant topic	Including Indigenous makers	Creating culturally identifiable experiences	Respecting indigenous protocols	Centering radical relationality in design

Specifically, we focus on Factor 2: Including Indigenous Makers (co-author, Ethnoastronomist, and Dakota Elder, James Rock), and Factor 3: Creating Culturally Identifiable Experiences [5].

Planetarium displays can be organized into a display ecology

Combining the planetarium, teacher, and student personal displays makes it possible to create a "**display ecology**" [4], an environment where multiple displays work together

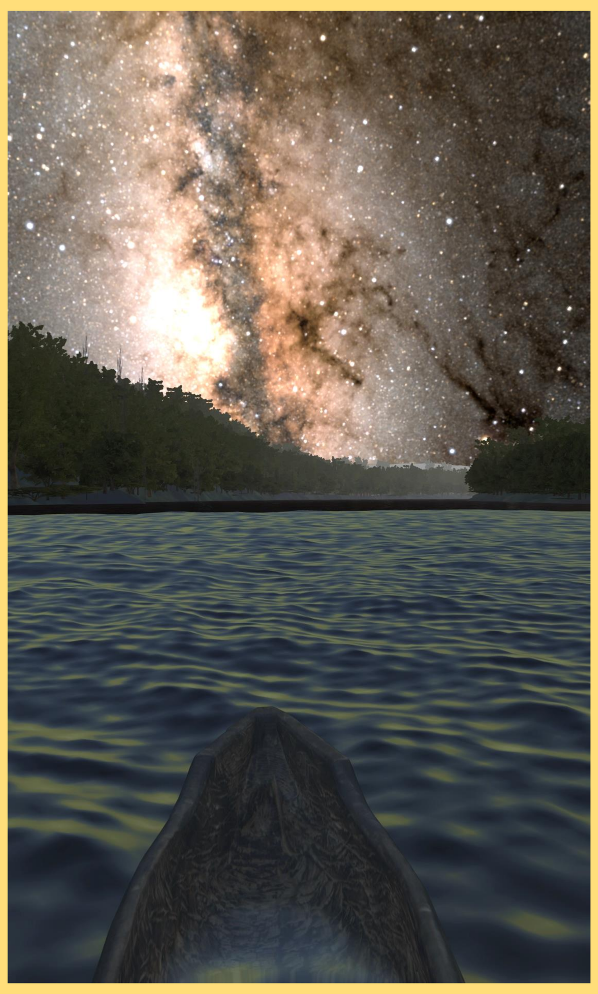
Planetarium dome as a collaborative display for the immersive star and land dataset



Teacher and student displays enable navigation of the dataset

Contributions

Applying Indigenous Presence with a data-driven approach



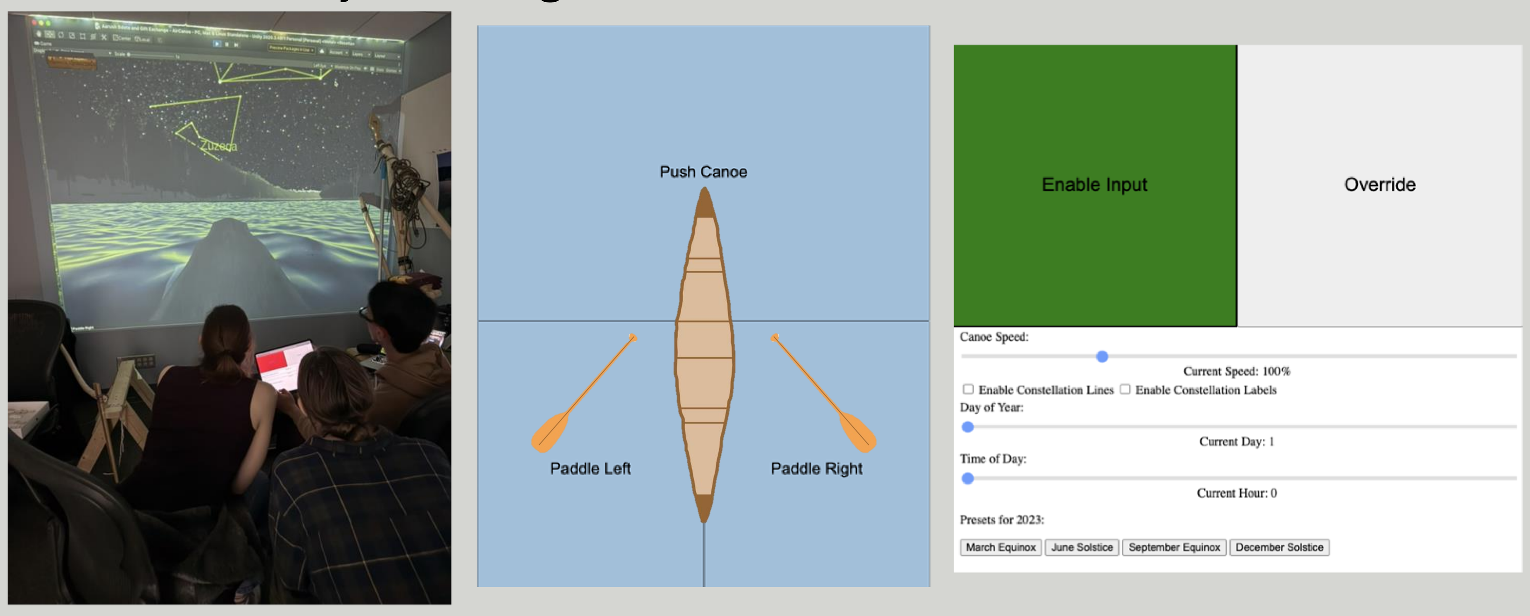
The Mississippi River with the Spirit Road/Milky Way reflected above, showing kapemni in CanoeView

- Using GIS data [1], we generated a pre-western settlement Bdote terrain model, which is the confluence of the Minnesota and Mississippi rivers
- A celestial model facilitates the addition of Dakota constellations
- Nasa deep star maps [2] give a detailed view of the night sky, including the Milky Way/Spirit Road
- Our goal is for the detailed sky and earth models to create a culturally identifiable experience for Dakota peoples.

Bdote terrain model [left] and Dakota constellations [right]. The Bdote is where the ancestors of the Dakota peoples originate

An early prototype collaborative canoe paddling simulation to navigate the immersive dataset

Using an input aggregation technique, which is a way of distilling many inputs into a single onscreen action, students use their device collaborate with each other and the storyteller to guide the canoe



Demonstration and feedback sessions with co-author Sarah Weaver [left], where user interfaces for students [center] and teachers [right] are qualitatively investigated

Visual immersion through a planetarium dome already has some potential benefits for learning [8] and we reason the input aggregation technique has the potential to further increase learning outcomes

Outlook and Future Work

While this work is an early example without formal analysis, based on qualitative feedback from our collaborators and co-authors, Sarah Weaver (St. Paul Public Schools) and James Rock (Dakota Ethnoastronomer and Elder), we have reason to believe that greater involvement of Dakota storytellers and collaborative approaches to storytelling have the potential to enhance learning outcomes and drive next-generation Indigenous computing and planetarium technologies.

Specifically, we see future research occurring in the following areas:

- Tangible User Interface (UIs) for canoeing interactions
- Networked Data Visualization Systems
- Multisensory Immersive Data Storytelling
- Group Interaction Data Visualization Design
- Input Aggregation Algorithms

Acknowledgements

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[1] Minnesota geospatial commons. https://gisdata.mn.gov/. Accessed: 2025-06-23. 2
[2] Nasa scientific visualization studio: Deep star maps 2020. https://svs.gsfc.nasa.gov/4851. Accessed: 2025-06-23. 2
[3] A. Bock, E. Axelsson, J. Costa, G. Payne, M. Acinapura, V. Trakinski, C. Emmart, C. Silva, C. Hansen, and A. Ynnerman. Openspace: A system for astrographics. IEEE Transactions on Visualization and Computer Graphics, 26(1):633–642, aug 2020. doi: 10.1109/TVCG.2019.2934259 1
[4] H. Chung, C. North, S. Joshi, and J. Chen. Four considerations for supporting visual analysis in display ecologies. In 2015 IEEE Conference on Visual Analytics Science and Technology (VAST), pp. 33–40, oct 2015. doi: 10.1109/VAST.2015.7347628 1, 2
[5] S. J. Dorr, J. W. Rock, V. M. Diaz, and D. F. Keefe. Toward indigenous presence: A radical relationality approach for designing mixed-reality indigenous data experiences. IEEE Computer Graphics and Applications, 44(6):61–69, jan 2024. doi: 10.1109/MCG.2024.3456868 1
[6] D. Maynes-Aminzade, R. Pausch, and S. Seitz. Techniques for interactive audience participation. In ACM SIGGRAPH 2002 Conference Abstracts and Applications, SIGGRAPH '02, p. 257. Association for Computing Machinery, New York, NY, USA, 2002. doi: 10.1145/1242073.1242270 1, 2
[7] J. Meeus. Astronomical Algorithms. Willmann-Bell, 1998. 2
[8] K. C. Yu, K. Saham, V. Sahami, L. Sessions, and G. Denn. Group immersive education with digital fulldome planetariums. In 2017 IEEE Virtual Reality (VR), pp. 237–238. Institute of Electrical and Electronics Engineers, 2017. doi: 10.1109/VR.2017.7892264 1