Work-in-Progress—Decolonizing the Digital Divide: Problem based spatial design through immersive technology for STEM education in Minority Populations

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***Abstract*— This work-in-progress paper reports preliminary findings from surveys, participant observation, and co-design discussions with educators and elders of a Native American community about how to modify STEM learning activities for their unique tribal culture in afterschool settings using immersive technology and spatial design.**

Index terms—native american, STEM, virtual reality, culturally relevant teaching

I. INTRODUCTION

When used in education, technologies such as Virtual Reality (VR) and Augmented Reality (AR) have been known to facilitate knowledge acquisition and increase the motivation of students to pursue Science, Technology, Engineering, and Mathematics (STEM) majors and careers [1]. Introducing students at an early age to these technologies will prepare them for the future workplace. In this paper, we share design based research reflections from a summer workshop for after school educators from 3 tribal nations. We use a Generative model of Culturally Relevant Teaching (CRT) that focuses on developing narratives and tools that inform students of cultural idioms through space and enable translations into creative architectural forms using the immersive nature of VR/AR technology. This paper reports findings from an intertribal educator workshop that uses the Spiro Mounds of Oklahoma, USA, as the context for VR/AR learning. The main research question focused on "In what ways can blended cultural learning and technology-rich immersive professional development support afterschool educator's abilities to translate Indigenous concepts into creative design experiences?" We report preliminary findings from pre-surveys, participant observation, exit tickets, and co-design discussions with elders and educators about how to modify the activity for their unique tribal culture and afterschool setting.

II. DECOLONIZING DIGITAL LANDSCAPE THROUGH EDUCATION

Research suggests that problem based spatial design education using VR/AR can motivate and prepare students for Science, Technology, Engineering, and Mathematics (STEM) careers [2], [3]. Additionally, VR/AR will be prominent technologies in many major STEM industries demanding a new set of skills for the emerging STEM workforce. However, while there is often inequitable access to Computer-Aided Design (CAD) in public schools and indigenous communities in the United States, there are also barriers in accessing knowledge given the colonized nature of science curricula [4]. Drawing on generative design principles, our project aims to design curriculum and implement culturally responsive CAD instruction for middle school youth and educators at tribal afterschool programs. This article reports findings from an intertribal educator workshop.

Digital decolonization refers to the effort to bridge the gap in digital practices as a means of limiting inequalities that existed in the past. According to [5], "the main feature of the Web 2.0 and 3.0 eras is moving beyond Digital Information to Digital Negotiation and Digital Creation" (p.400). Marginalized groups should move from digital recipients to become active participants of the digital environment by creating and sharing of information that might be particular to their cultural heritage. With the era of web 2.0 and 3.0, there is representation of indigenous groups in the digital world, however there is still a divide in terms of access and representation [6]. To examine the divide, we would need to look through the lens of equity to examine the gap between what indigenous groups and non-indigenous people can do and what cannot be done, the difference in the access to knowledge (education) and technology in schools and home environment, and most importantly the influence of culture in education, and its influence on the underrepresentation of Native Americans in STEM fields [7].

CRT as a specific pedagogy allows the cultural references, ideas, and experiences of students to be an important part of the learning process [8]. Presenting science in culturally relevant frameworks can increase Native American participation in STEM learning and this includes after-school science education experiences [9]. Generative models of CRT [10] focus on developing narratives that inform students of cultural idioms and translates into creative architectural forms through the use of the immersive nature of VR/AR technology. These experiential learning opportunities can allow the students to explore their cultural heritage, develop new milieus that are relevant to their generation, and develop an appreciation for technology and its capabilities. Literature informs us about some of the underutilized systemic strategies that have been documented to work with Native American students and their learning environments, such as collaborative learning, more inclusive and diverse learning environments, and using culturally relevant pedagogy, research, and evaluation processes [11]. Therefore, it is important to develop content that is culturally relevant and embodies the worldview that Native Americans embrace, through concepts that are used in daily lives and in a hands-on-situated learning background.

III. Space As A Generative Learning Concept

Space is a central characteristic of all human activity [12]. People experience space in different ways and at different levels- therefore, space plays a fundamental role in developing culture and social connections [13]. Space and its constructs are a central theme when discussing any civilization and become a visual cue for these ancient cultures. According to Hall's theory of proxemics [14], the way individuals perceive space depends on their cultural background. Space is a function of an individual's culture and it is possible to express cultural characteristics through these spatial metaphors.

The importance of this idea of space as a metaphor for culture is taken a step further by [15] through the concept of Genius Loci or the Spirit of Place , which is described as what makes a space specific as well as the dimensions of lived experience, interaction, and use of space [16]. The spirit - or sense - of place usually refers to what makes a space specific to the individual, such as the characteristics, memories and associations, and activities afforded by the place. Sense of place is defined as the emotional relationships and meanings attributed to the space [17]. However, while the personal and relational dimensions relate to the space, they can also apply to the place since place refers to the mental environment. This is due to the "experiences-in-place" being able to evoke significant feelings involving the perceived place. These feelings can be discussed under three categories: experiences of personal growth, memories, and feelings of safety, threat, and belonging [16]. Therefore, the idea of using space as a cultural metaphor is not new, and has been used in different domains including STEM education.

IV. Methods & Data Collection

The project follows an iterative process of design, implementation, research/evidence, feedback, and adjustment of program components. This process is commonly referred to as Design Based Research (DBR), which is focused on improving "educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories [18].

Seven (n=7) afterschool educators from three tribal nations participated in the three-day workshop and were provided a stipend for their participation. A pre-survey was used to better understand their prior STEM teaching experiences and instructional comfort with STEM education, as well as teaching beliefs about technology. Observational data was collected and analyzed using video recordings of the workshop. Educators were asked to complete exit tickets each day to capture individual reflections about the workshop content. Finally, educators participated in a group brainstorm with the workshop hosts to identify specific tribal nation connections and synergies with existing cultural programming at the afterschool. The first day the focus was providing the educators with some background of CRT pedagogy and providing them with an introduction to Spiro Mounds, its Architecture and the cultural significance. The researchers provided information by inviting the curator for the Spiro Mounds Museum and presenting the participants with an overview of the Spiro Mounds. The discussions focused mainly on the structure of the spiro mounds and the artifacts that were entombed within the mounds. The discussion also focused on the cultural significance of the mounds to all tribes in Oklahoma, as it embodied aspects of all tribes of the Mississippian settlements.

During this first day the educators were provided with basic instruction on how to use Sketchup and explore the 3D models using VR through the Enscape plugin. Furthermore, some of the artifacts (replications of actual artifacts found in the mounds) that the curator brought were 3D scanned using a handheld 3D scanner.

The second day was focused on recreating the Spiro Mounds using Sketchup. The after school educators developed the 3D model of the Spiro Mounds using information on the structure provided by [21]. The artifacts that were 3D scanned were then included inside the 3D model of the mound.

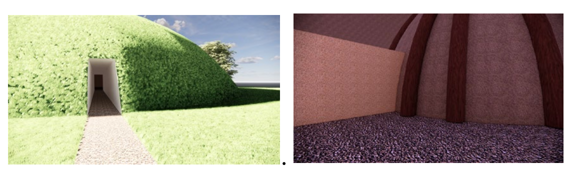

Fig. 1. Exterior and Structure of the Spiro Mound (rendered 3D model)

During this experience, the intention was for the educators to combine the cultural aspects of the Spiro Mounds with the technical details of developing 3D models and finally experiencing these cultural artifacts through immersive VR. A culturally responsive method was utilized for the educators to construct knowledge rather than just passively take in information by developing the Spiro Mound using Sketchup. Then the educators experienced the Spiro Mound using VR, where they built their own representations and incorporated new information upon their pre-existing knowledge of the Spiro Mounds.

The third day was utilized for the co-design of the educational modules of the after school program. In DBR, collaborative design, or co-design, is one strategy for utilizing teachers' expertise to design, implement, and test educational outcomes, thereby strengthening teachers' agency. This process also allowed the researchers to understand what is familiar to students in the context of that particular after school community and also allowed them to create STEM connections to already existing cultural learning activities.

V. Findings and Conclusions

To answer our main research question, we introduced generative design and CRT to our after-school educators. Our intertribal educator workshop set the stage for exploring spatial design across cultures, and codesign with CPN elders and educators.

Most of the teachers (86%) have a Bachelor's Degree or Higher. While their years of experience in STEM ranged from 2-13 years, most (86%) felt comfortable or somewhat comfortable implementing STEM and Technology activities. Notably, of the 3 partner tribal nation afterschool programs, 2 programs devoted less than 20% of the time on STEM learning, while the other program reported more than 50% focus on STEM. Already existing STEM activities used in the afterschool programs included having lectures and guest speakers, small group and/or outdoor activities, participating in engineering design challenges, and having robotics competitions. These findings overall demonstrate how the amount of experience of the teachers, commitment to STEM education, and available resources varied across each afterschool program.

The third day of the educator workshop was focused on creating co-designed connections. The educators gave insight into the interests of the students, and the activities/projects in progress at the afterschool program. For example, it was through the educators that knowledge of the students' bead working was learned. The idea to create a museum to showcase this work became the objective of module three.

The DBR process allowed for the afterschool modules to be modified. Initially, it was the plan to have the students learn about and create a 3D model of the Spiro Mounds. After discussion with the after school educators, it was determined this would not be a realistic goal since the Oklahoma Native American Tribe's students had little to no experience with 3D modeling software.

We learned that an important component of generative design is to develop relationships with cultural knowledge bearers and tap into existing after school cultural activities. For several tribal nations, administrative units dealing with cultural preservation and language are not necessarily used to collaborating or working in the after school setting. In the future, we will continue to encourage educators to actively identify cultural knowledge bearers, community based problems, and other stakeholders for the hack-a-thon which is introduced in the final module.

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References

[1] T. Restivo, F. Chouzal, J. Rodrigues, P. Menezes, and J. Bernardino Lopes, "Augmented reality to improve stem motivation," *2014 IEEE Global Engineering Education Conference (EDUCON)*, 2014.

[2] N. Pellas, A. Dengel, and A. Christopoulos, "A scoping review of immersive virtual reality in STEM education," *IEEE Transactions on Learning Technologies*, vol. 13, no. 4, pp. 748–761, 2020.

[3] E. Nersesian, A. Spryszynski, and M. J. Lee, "Integration of virtual reality in secondary STEM education," *2019 IEEE Integrated STEM Education Conference (ISEC)*, 2019.

[4] R. Santo, L. A. DeLyser, J. Ahn, A. Pellicone, J. Aguiar, and S. Wortel-London, "Equity in the who, how and what of Computer Science Education: K12 School District Conceptualizations of equity in 'cs for all' initiatives," *2019 Research on Equity and Sustained Participation in Engineering, Computing, and Technology (RESPECT)*, 2019.

[5] P. J. Meighan, "Decolonizing the digital landscape: The role of technology in indigenous language revitalization," *AlterNative: An International Journal of Indigenous Peoples*, vol. 17, no. 3, pp. 397–405, 2021.

[6] J. J. George and D. E. Leidner, "Why marginalized groups struggle to leverage digital activism," *Americas Conference on Information Systems 2018, Digital Disruption, AMCIS 2018*, vol. 24th Americas Conference on Information Systems 2018: Digital Disruption, AMCIS 2018 - New Orleans, United States, no. 2018 Aug 16 → 2018 Aug 18, Jan. 2018.

[7] D. H. Williams and G. P. Shipley, "Cultural taboos as a factor in the participation rate of Native Americans in STEM," *International Journal of STEM Education*, vol. 5, no. 1, 2018.

[8] G. Ladson-Billings, "Toward a theory of culturally relevant pedagogy," *American Educational Research Journal*, vol. 32, no. 3, pp. 465–491, 1995.

[9] S. Stevens, R. Andrade, and M. Page, "Motivating young native American students to pursue stem learning through a culturally relevant science program," *Journal of Science Education and Technology*, vol. 25, no. 6, pp. 947–960, 2016.

[10] R. Eglash, M. Lachney, W. Babbitt, A. Bennett, M. Reinhardt, and J. Davis, "Decolonizing education with Anishinaabe arcs: Generative stem as a path to Indigenous Futurity," *Educational Technology Research and Development*, vol. 68, no. 3, pp. 1569–1593, 2019.

[11] N. R. Bowman, "Cultural differences of teaching and learning: A Native American perspective of participating in educational systems and organizations," *The American Indian Quarterly*, vol. 27, no. 1, pp. 91–102, 2003.

[12] National Research Council. Community and quality of life: Data needs for informed decision making. National Academies Press.. 2002

[13] D. T. Do, Y. Cheng, A. Shojai, and Y. Chen, "Public park behaviour in da nang: An investigation into how open space is used," *Frontiers of Architectural Research*, vol. 8, no. 4, pp. 454–470, 2019.

[14] E. T. Hall, "The hidden dimension," *Leonardo*, vol. 6, no. 1, p. 94, 1973.

[15] H. N. Forusz and C. Norberg-Schulz, "Genius loci," *JAE*, vol. 34, no. 3, p. 32, 1981.

[16] L. Lentini and F. Decortis, "Space and places: When interacting with and in physical space becomes a meaningful experience," *Personal and Ubiquitous Computing*, vol. 14, no. 5, pp. 407–415, 2010.

[17] A. Campelo, "Rethinking sense of place: Sense of one and sense of many," *Rethinking Place Branding*, pp. 51–60, 2014.

[18] F. Wang and M. J. Hannafin, "Design-based research and technology-enhanced learning environments," Educational Technology Research and Development, vol. 53, no. 4, pp. 5–23, 2005.