Hawaii ICC Workshop Final Report

Summary information

Workshop: Integrating Indigenous Knowledge and Creative Computational Media: Building a Sustainable Innovation Ecosystem in the Pacific Rim
Dates: August 12, 13, 2024
Location: Kapolei, Oahu, Hawaii
Venue(s): University of Hawaii West Oahu
Region: Pacific Rim
Web site: https://www.lavaflow.info/icc-workshop
Organizing committee:
- Jason Leigh - Laboratory for Advanced Visualization & Applications, Create(x), University of Hawaii at Manoa
- Kamuela Enos - Office of Indigenous Knowledge and Innovation, University of Hawaii
- Chris Lee - Academy for Creative Media System, University of Hawaii
- Nurit Kirshenbaum - Creativity and Technology Lab, University of Hawaii at Manoa
- Kari Noe - LAVA, Create(x), University of Hawaii at Manoa
- Pamuel Taura - ACM, University of Hawaii
- Shivani Tanaka - Information & Technology Center, University of Hawaii at Manoa

Total participant count, excluding organizing committee: 53

Public summary

The workshop convened leading Indigenous practitioners, artists, and members of creative media industries—including film and video game companies—as well as educators and researchers in creative computational media from Pacific Rim regions like Hawaiʻi, California, Washington, and New Zealand, or those conducting research involving the Pacific Rim.

The goal was to explore the challenges and opportunities in establishing an Indigenous Creative Computational Media Innovation Ecosystem (ICCMIE) and to provide recommendations to the National Science Foundation on substantively including Indigenous groups in future programs related to cultural creativity and innovation.

This workshop was timely because rapid globalization threatens the preservation of Indigenous cultural heritage, languages, and ancestral knowledge. Indigenous wisdom, which has sustained regenerative communities for millennia, offers valuable insights to counteract the anthropocentric and extractive practices driving crises such as climate change. While new economic models rooted in Indigenous values are essential for sustainability, integrating emerging technologies poses challenges as well as creates many opportunities.

Developing a creative computational media economy centered on Indigenous practices in regions like Hawaiʻi could mitigate brain drain and promote sustainable economic development. Digital media, being weightless and easily distributable, offers a viable alternative to physical manufacturing. The fact that recent films about Hawaiʻi are produced elsewhere due to better infrastructure and tax incentives highlights the detrimental effects of this gap.

The ICCMIE emerged as a framework to integrate Indigenous epistemology with creative media, fostering a symbiotic relationship between technology, culture, and environment. It aims to preserve Indigenous cultural contexts, generate high-quality local jobs, and authentically share Indigenous stories. Workshop participants emphasized the vital connection between land and people, noting that revitalizing Indigenous culture through creative media can empower communities, facilitate knowledge transmission, and contribute to more sustainable innovation ecosystems.

Technologies and S&E Skills

- Creative Computational Media
- Virtual Reality
- Augmented Reality
- Computational Photography
- Computational Imaging
- Natural Language Processing
- Data Visualization
- Data Physicalization
- Tangible Computing
- Game Design
- e-Sports

Cultural Domain and Creative Skills

- Film media archive enhanced with LLMs to facilitate intelligent archival search and also providing an embedded social media capability to link old with the young (e.g. 'Ulu'ulu [Ulu]).
- Training and creation of generative AI (both Large Language Models and Visual Language Models) that is informed by indigenous practices.
- Viscerality Recording, Animation, and Dissemination of indigenous cultural and knowledge.
- Continued generation of media that can aid in language revitalization (i.e. generative subtitles, text-to-speed, etc.)
- Development of video games (both serious games and for entertainment) that includes the learning of indigenous knowledge or values to progress or play.

Hawaiʻi Innovation Culture & Creativity Workshop Agenda

G102 - Lobby**; G110** - E-Sports**; G111** - Flex Classroom;
G129 - Create(x) / Emerging Media**; G131** - Screening Room

Day 01

Time	Activity	Location
8:30	Breakfast	G102
9:00	NSF Workshop Pre Survey (Sam Bourgault) - 20 mins https://go.hawaii.edu/Afa Launa ("Introductions") - Hawaiian Opening / Setting Intentions - 5 min (Kamuela Enos) - Welcome by the Chancellor (Maenette Benham)- 5 min - Intro to PI/Co-PIs (Jason Leigh, Kamuela Enos, Chris Lee, Nurit Kirshenbaum, Kari Noe, Shivani Tanaka, Pamela Taura) - 5 min - National Science Foundation (Chaitan Baru) - 5 min - Instructions for the day (Jason Leigh) - 5 mins	G131
9:45	Hōʻike Piko ʻŌ (showcase of ancestral perspectives)- Ancestral Practices as Sciences (Kuhaʻo Zane)	G131
9:55	Hōʻike Piko ʻĪ (showcase of current perspectives) (Kamuela Enos)	G129
10:05	Hōʻike Piko ʻĀ - (showcase of future perspectives) Indigenous Data Hubs (Kari Noe) [G129] - Half participants go to Create(x) Creative Media Innovation (Nikora Ngaropo) [G131] - Half participants stay in theater	G129 & G131
10:20	Groups switch between G129 and G131	G129 & G131
10:35	Introduction to Noho - (Charlie Love)	G131
10:45	Break	G102
11:00	Noʻonoʻo (*lit.* "deliberate") #1 - Indigenous Research, Design, and Innovation Practice (Kamuela Enos lead)	G131
12:00	Group Photo & Lunch	G102
12:45	Noʻonoʻo #2 - Creative Computational Media Research (Jason Leigh lead)	G131

Time	Activity	Location
1:45	Noʻonoʻo #3 - Creative Workforce Development (Chris Lee lead)	G131
2:45	Break	G102
3:00	Group Convergence Activity (Parallel Sessions)	G131 (C), G110 (I), G111 (W)
4:00	Presentation Summary of Group Convergence Activities (5 mins per group)	G131
4:15	Adjourn	G102

Day 02

Time	Activity	Location
8:30	Breakfast	G102
9:00	Review Day 1, Charge for Day 2	G131
9:30	Group Convergence Deep Dive (Parallel Sessions)	G131 (C), G110 (I), G111 (W)
10:45	Break	G102
11:00	Group Writing of Convergence Deep Dive (Parallel Sessions)	G131 (C), G110 (I), G111 (W)
12:30	Lunch	G102
1:45	Presentation of Group Findings	G131
2:15	Closing & NSF Exit Survey for Attendees https://go.hawaii.edu/af3	G131
2:30	Synthesis Writing (core writing team only: Jason Leigh, Chris Lee, Nurit Kirshenbaum, Kamuela Enos, Kari Noe, Shivani Tanaka) NSF Organizer In-Person Interview (Sam Bourgault, Jason Leigh only)	G131
4:00	Adjourn	

2024 Hawaiʻi Workshop on Innovation, Culture, and Creativity
Attendee Contact Information

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A. Narrative Summary of Reflections and Discussions from Workshop

The rapid pace of globalization and the resulting dispersion of Indigenous peoples in search of better job opportunities and/or lower costs of living poses a significant threat to the preservation of Indigenous cultural heritage, languages, and ancestral knowledge. This pressure that breaks apart communities risks the loss of Indigenous wisdom that has cultivated sustainable and regenerative communities for millennia. Such wisdom holds invaluable lessons that could help counteract the extractive and anthropocentric practices predominant in global economies, that have led to issues such as climate change induced extreme weather events, drought, and wildfires.

There is a pressing need to develop new economic models that are inclusive, deeply rooted in Indigenous values, and sustainable. These models must move away from the extractive and inequitable norms that have characterized previous attempts to integrate Indigenous communities into the economy, aiming instead for meaningful inclusion and leadership. Within the realm of the creative sector, this means co-design and Indigenous-led creation of creative computational media by Indigenous communities.

However, it was identified by many of our participants that integrating emerging technologies into these new economic frameworks requires robust cyberinfrastructure—a significant challenge in areas like Hawaiʻi, where educational institutions are notably under-resourced in advanced computing capabilities. Furthermore, given the logistical and cost barriers associated with manufacturing physical products in Hawaiʻi, leveraging its status as a renowned movie filming location to develop a creative computational media economy is a strategic move. Digital media, being largely weightless and easily distributable, offers a sustainable economic alternative that can be globally dispersed with minimal logistical effort.

This strategic shift would not only help revitalize and perpetuate Indigenous cultural contexts but also provide high-quality, local job opportunities that are currently found overseas. As an example that was

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discussed in our workshop, recent media productions that thematically concern Hawaiʻi (such as, The King- a film about the unification of the Hawaiian islands by King Kamehameha) were filmed in New Zealand, where infrastructure for creative computational media and tax incentives are more prevalent; the export of production is detrimental to both the authenticity of the media and the human talent that would have benefited from these projects.

Thus, we established the concept of Indigenous Creative Computational Media Innovation Ecosystem (ICCMIE). An ICCMIE integrates the principles of a specific (pursuant to an affiliated community) Indigenous epistemology and biocultural restoration with creative computational media to foster a symbiotic relationship between technology, culture, and the environment. To continue to use Hawaiʻi as an example, an ICCMIE can mitigate brain drain, foster sustainable economic development, and allow its Native Hawaiian communities to create media that authentically carries their unique wisdom, stories, and experience in ways that cultivate community knowledge-transmission as well as share what are deemed appropriate representations with the world. Our hope is that this will, in turn, strengthen the biocentric ethos of the broader populations in which Indigenous communities reside, helping to drive the shift toward more diverse and sustainable innovation ecosystems. With the existence of an ICCMIE, future Indigenous students will be encouraged to enter the STEAM workforce, where they will be able to apply both their technical skills (such as programming or filmmaking) and their ancestral knowledge, enriching their careers and contributions to the field.

Workshop participants agreed that at the heart of the ICCMIE approach is the imperative link between land and people. The health of the land is tied to the health of its people. Reconnection and revitalization of culture through creative media not only heals and empowers people, but also helps foster a reconnection to their ancestral lands. By synergizing Indigenous communities' knowledge and contemporary technologies, there lies an opportunity to bring unique knowledge, stories, and practice to enrich local communities and bring media to the global stage in ways that are equitable to the Indigenous communities who would like to share their knowledge with the world.

B. Core Ecosystem Principles

When working with Indigenous communities it is important to be clear that collaborative conversations are not bridging cultures, but epistemologies. Meaning that two distinct worldviews are being merged, and that the onus is on the dominant system (if it aspires to establish a restorative relationship with Indigenous communities it has historically marginalized) to not assume that their frameworks translate easily with those held by their prospective Indigenous partners. Underpinning all of the following principles needs to be an overarching principle of equity, embodied as a willingness from contemporary institutions of postsecondary education to understand the epistemological differences and modes of engagement between community and university as an iterative and consent based conversation that spans the entirety of the partnership's life.

We identified a lens for equity-based engagement of marginalized Indigenous communities. Partners must accept Indigenous ancestral practice as a corpus of knowledge that has frameworks, methodologies and applied systems that have been optimized through the course of time to seamlessly integrate human and natural systems, thus the emergence of contemporary "bio-cultural" nomenclature.
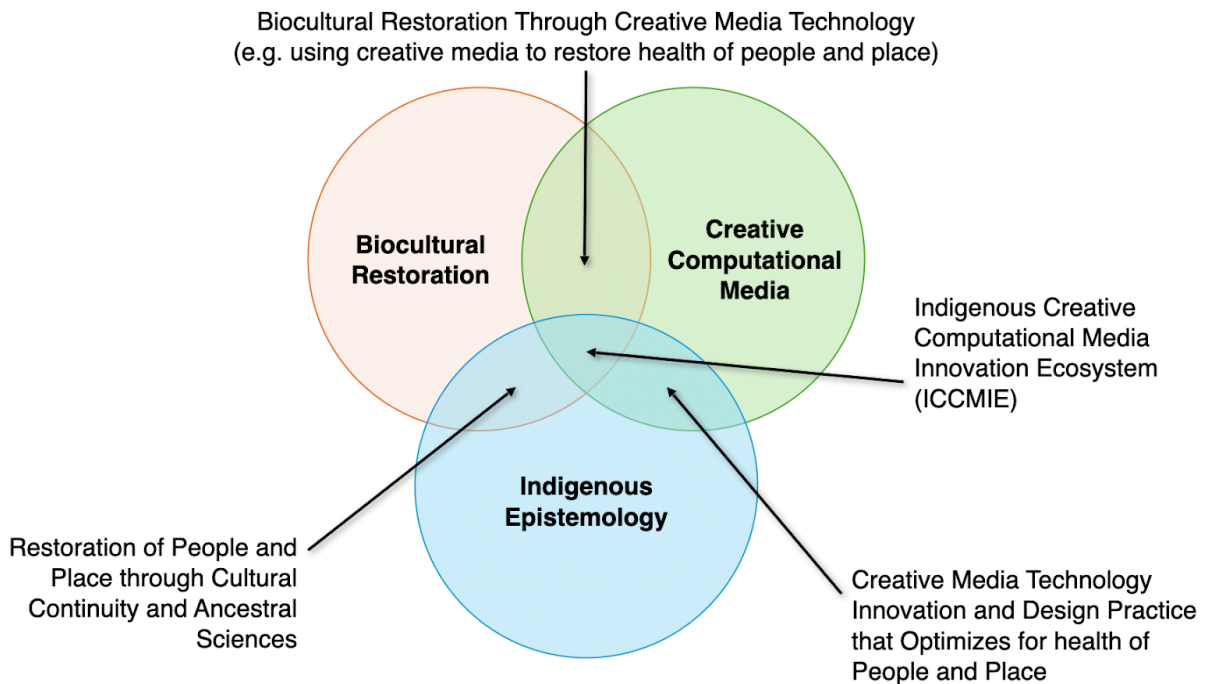
Indigenous Epistemology

Central to an ICCMIE model is the recognition and integration of Indigenous knowledge systems. This includes understanding traditional ecological knowledge, ancestral ways of knowing, and biocentric practice and values.

Biocultural Restoration

The restoration of healthy ecosystems which includes the restoration of human and cultural connections to place. This involves leveraging creative computational media to protect and revitalize natural environments, perpetuate cultural heritage, and re-establish connections between people and their ancestral lands [Kimmerer2000].

Creative Computational Media

Using advanced digital tools and platforms to express, preserve, and innovate within Indigenous communities' contexts. This can include VR, AR, generative AI, natural language processing, computational photography, digital storytelling, and other forms of computational creativity [Mateas2005].

Biocultural Restoration Through Creative Media Technology
(e.g. using creative media to restore health of people and place)

Biocultural Restoration

Creative Computational Media

Indigenous Creative Computational Media Innovation Ecosystem (ICCMIE)

Indigenous Epistemology

Restoration of People and Place through Cultural Continuity and Ancestral Sciences

Creative Media Technology Innovation and Design Practice that Optimizes for health of People and Place

There is growing interest in understanding how biocultural restoration can create an innovation ecosystem centered on creative computational media. While the research connecting these fields is still evolving, several studies and projects provide insights into how traditional ecological knowledge, ancestral practices, and digital media can converge to foster innovative ecosystems [Citation Group A].
There is research showing that creative computational media is a good economic driver for Hawai'i. Several studies and reports underscore the sector's significant contributions to job creation, economic diversification, and the development of an innovation ecosystem in the state [Citation Group B].

There is research that shows that creative computational media is a good area of focus for Indigenous communities in the Pacific Rim. This field offers significant potential for cultural preservation, economic development, and empowerment, utilizing digital storytelling, multimedia, and technology innovation to engage with global markets while revitalizing cultural heritage [Smith2012].

C. Challenges and Needs

While progress has been made in integrating creative computational media within Indigenous communities in the Pacific Rim, we identified key challenges related to funding and distribution systems, such as those of the NSF, which we aim to address in this report.

Infrastructure and Access

Challenge 1: Many Indigenous communities face significant barriers to participating in creative computational media due to limited access to essential cyberinfrastructure, including high-speed internet, computing resources, and advanced digital media tools. However, initiatives such as the Broadband Equity, Access, and Deployment Program ($45B nationwide, $149.5M for Hawaii), alongside NSF's International Research Network Connections program, which provides high-speed connectivity between U.S. educational institutions and their international counterparts, show that infrastructure improvements can help overcome these challenges. Similar investments are needed for other Indigenous communities to fully engage in digital creativity.

Advanced digital media tools—like the Volume[1] - panoramic media walls used in the production of Disney's "The Mandalorian" or immersive environments created by Teamlab—are often dismissed by NSF reviewers as extravagant. However, it's crucial to recognize these tools as vital research instruments, enabling future generations of Indigenous students to excel in creative computational media. These tools have transformative potential. For instance, NSF's early investment in technologies such as the CAVE[2] and CAVE2[3] led to their widespread use in the film[4] and automotive industries[5]. Once considered niche, these innovations helped conceptualize entirely new applications for immersive environments.

Additionally, spaces like Create(x)[6] are emerging as vital environments where students can learn these processes and innovate new techniques. The rise of immersive experience spaces such as Netflix House[7], the Sphere[8], the Illuminarium[9], and teamLab[10] underscore the growing popularity of these media environments, highlighting the potential for Indigenous students to be trained as the future content creators of these immersive worlds. It is clear that these immersive environments are not only

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[1] The Volume: https://techcrunch.com/2020/02/20/how-the-mandalorian-and-ilm-invisibly-reinvented-film-and-tv-production
[2] The CAVE: https://en.wikipedia.org/wiki/Cave_automatic_virtual_environment
[3] CAVE2: https://www.mechdyne.com/av-vr-solutions/case-study/raytheon/
[4] https://www.theverge.com/2015/8/13/9131805/ilm-ilmxlab-interview-virtual-reality-star-wars-movies
[5] https://www.asme.org/topics-resources/content/manufacturing-cars-with-virtual-reality
[6] Create(x): https://www.lavaflow.info/createx
[7] Netflix House: https://www.today.com/video/netflix-house-to-open-in-2025-what-fans-can-expect-213268037565
[8] The Sphere: https://www.thesphere.com
[9] The Illuminarium: https://www.illuminarium.com
[10] teamLab: https://www.teamlab.art

experimental labs but also platforms for communicating NSF science to the general public in accessible and engaging ways. Unlike traditional linear media, immersive environments such as Create(x) are uniquely suited to visualizing indigenous knowledge and storytelling.

Create(x) (top left), the Sphere (top right), the Illuminarium (bottom left), TeamLab (bottom right)

Challenge 2: While successful creative computational media projects exist, many remain localized and need to be scaled up to reach broader audiences or influence state/national investment policy.

Fostering knowledge exchange and collaboration between Indigenous communities, as well as scaling up pilot projects and replicating successful models across regions, can further strengthen these efforts. Establishing regional networks and alliances will amplify the impact of creative computational media initiatives, driving innovation and inclusion in underrepresented areas.

See recommendations:
1: "Invest in Indigenous Creative Computational Media Innovation Hubs".
7: "Foster Collaborative Networks Across the broader Pacific Rim"

Workforce Development

Challenge 3: There is a need for more educational/training programs tailored to Indigenous contexts, focusing on digital literacy, coding, digital storytelling, and multimedia production. Culturally relatable educational programs are shown again and again to be effective [Atwater1993, Ogawa1995, Snivley2000]. More importantly, building capacity for technology has to coincide with training personnel that will use and maintain it. To support the Indigenous heart of the suggested ICCMIE, personnel should be rooted in the Indigenous community.

There are currently not enough culturally relevant curricula that blend ancestral knowledge with creative computational media skills. Developing such programs will need to include funds for establishing training centers and supporting mentorship programs. Partnerships with educational institutions to create opportunities for Indigenous students to engage in creative computational media are also essential.

See recommendations:
1: "Invest in Indigenous Creative Computational Media Innovation Hubs".
2: "Support Indigenous-Centered Research and Development"
3: "Develop Education and Workforce Programs"

Long Term Sustainability

Challenge 4: Many Indigenous STEM initiatives are given short term funding to develop a research project. To create an innovation ecosystem, the preconditions for this ecosystem (i.e. student development, infrastructure, etc.) must also be invested in.

Indigenous communities want to have an opportunity to have ecosystems to articulate and innovate on technology derived from their ancestral frameworks that they deem valuable to their communities.

The willingness to invest in an Indigenous innovation ecosystem is different then providing line items to fund Indigenous-centerd projects. So the challenge becomes identifying the components that must be collaboratively invested in for sectoral development. Singular research projects in isolation won't be able to scale without the proper surrounding environment to reach system change. Institutional funders like NSF can normalize this type of investment by committing funding to this holistic idea, which de-risks it for other institutions and organizations to support this community-derived framework.

For example, initiatives that require physical facilities may require the cost of renting and equipment, mentorship programs may require salary payment for personnel, hardware installations may require funds for upgrades or replacements, and software tools may require them for development and customization. Without long-term provisions, projects are less likely to have real effects on the receiving communities.

See recommendations:
4: "Support Indigenous Entrepreneurship and Commercialization"

System Change Challenges

System change involves a comprehensive transformation of processes, structures, and mindsets within a sector. Provided below are identified challenges that must be addressed to create an ICCMIE.

Challenge 5: Existing innovation ecosystems may align well with the values, priorities, and practices of Indigenous communities, leading to a mismatch between economic opportunities and cultural revitalization and perpetuation goals. The notion of "global competition" is problematic to Indigenous communities. Indigenous communities are not competing with other countries or each other, but competing against systems that are bringing them to the brink of collapse/demise. From an indigenous perspective, to be competitive one must create ecosystems that do not perpetuate harm, genocide, or erasure but instead foster innovation and the continuation of indigenous practices that are optimized for sustainability and allows for diversity of thought.

Challenge 6: The protection of Indigenous intellectual property and cultural assets in the digital space remains a significant concern. There is severe risk of cultural appropriation or exploitation when cultural content is shared through digital platforms.

It is problematic when Indigenous intellectual property (that is traditionally held in trust by a community) is claimed by a private business. For example, Disney is infamous for its attempts to trademark phrases or words that were created and belonged to communities such as "Dia de los Muertos[11]" and "Hakuna Matata[12]." It is difficult for Indigenous communities as a collective to protect their intellectual property from appropriation and exploitation when local ways of claiming and exercising IP is not clearly recognized in local government. On a global scale, organizations like the World Intellectual Property Organization, are still working on negotiations to finalize agreements on international legal instrument(s) relating to intellectual property to set a precedent for the protection of Indigenous Intellectual Property [Citation Group D].

The concept of Indigenous intellectual property fundamentally differs from existing intellectual property guidelines because Indigenous IP is collective, while most current IP frameworks are individualistic. Contemporary IP systems, such as copyright, patents, and trademarks, focus on protecting the creations of individual inventors, artists, or companies, assigning ownership to a single entity for economic value and innovation, protecting works for their potential to generate profit or distinguish a brand. In contrast, Indigenous IP is grounded in community ownership, where cultural knowledge, ancestral practices, and artistic expressions are held collectively by entire communities, spanning generations that have community and cultural significance, rather than strictly economic value.

Designing innovation ecosystems that prioritize cultural values, ancestral knowledge, and collective ownership is essential for fostering Indigenous creativity and resilience. These ecosystems should create spaces for collaboration, where Indigenous creatives, technologists, and people of all generations can co-create projects that align with community goals. Equally important is supporting leadership development within these ecosystems to ensure sustained growth and direction. Strengthening legal frameworks and establishing community-led protocols to govern the use, sharing, and commercialization of Indigenous knowledge is also critical. Initiatives like community-controlled archives and digital repositories, such as 'Uluʻulu [Ulu], play a vital role in preserving data sovereignty in the digital age.

See recommendations:
1: "Invest in Indigenous Creative Computational Media Innovation Hubs".
5: "Promote Digital Sovereignty and Data Governance"

Policy Support and Advocacy

Challenge 7: There is a need for more research that tracks the social, cultural, and economic impacts of creative computational media projects in indigenous communities.

Advocating for policies that prioritize Indigenous innovation and allocate resources to creative computational media initiatives is crucial for empowering Indigenous communities. Indigenous voices must be included in technology and innovation policy discussions at regional, national, and global levels to ensure their perspectives and needs are addressed. Additionally, developing culturally appropriate

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[11] https://www.cnn.com/2013/05/10/us/disney-trademark-day-dead/index.html
[12] https://www.nytimes.com/2018/12/20/world/africa/hakuna-matata-disney-trademark.html

metrics to evaluate the success of these initiatives—focusing on not only economic growth but also cultural revitalization, community well-being, and intergenerational knowledge transmission—is essential. Co-producing research with Indigenous scholars and practitioners is key to creating meaningful and sustainable outcomes for these communities.

See recommendations:
2: "Support Indigenous-Centered Research and Development"
6: "Advocate for Indigenous Sensitive Review Criteria for Intellectual Merit and Broader Impact"

D. Opportunities

Creative computational media offers significant opportunities for Indigenous communities in the Pacific Rim to drive cultural revitalization, economic development, and technological innovation. These opportunities can help biocultural restoration, build economic resilience, and enable participation in global innovation ecosystems, empowering Indigenous communities to lead culturally grounded innovation.

New Opportunities for Economic Development

Advocating for policies that support Indigenous creative industries can lead to funding, infrastructure investment, and sustainable business models that align with cultural values. These efforts can promote long-term sustainability and cultural resilience within indigenous communities.

The global creative economy is rapidly growing[13], offering Indigenous communities valuable opportunities to create culturally grounded digital content for both local and international markets. Indigenous-owned businesses and startups can thrive by producing multimedia content, digital art, and games that reflect their cultural values, generating sustainable revenue streams and job opportunities within their communities. Incorporating creative computational media into education allows Indigenous students to merge ancestral knowledge with modern digital skills, and culturally relevant STEAM programs can teach coding, design, and media production through a cultural lens, inspiring Indigenous youth to lead in technology and creative industries [Citation Group E]. Engaging young people in digital storytelling and creative expression empowers the next generation of Indigenous technologists, artists, and entrepreneurs. Establishing culturally aligned innovation hubs or co-working spaces dedicated to creative computational media can further support Indigenous creatives and entrepreneurs, serving as centers for community-driven innovation and offering resources, mentorship, and collaboration. Regional and international hubs can facilitate knowledge exchange, partnerships, and access to funding and markets.

New Opportunities for Equitable Research

Positioning Indigenous communities at the forefront of emergent innovation offers a transformative approach, allowing them to lead in shaping culturally relevant technologies and media. Equitable research is essential in this process, ensuring that Indigenous voices and perspectives are fully integrated into collaborative projects. When Indigenous knowledge holders, artists, and technologists work together in a balanced, respectful partnership, they can develop technologies and media that are culturally aligned and deeply meaningful. Indigenous-led research that explores the intersection of traditional knowledge and

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[13] The US creative sector contributed about $1.1T to US GDP in 2022.
Estimated creative economy could account for 10% of global GDP by 2030.
https://www.arts.gov/news/press-releases/2023/new-data-show-economic-activity-us-arts-cultural-sector-2021

creative computational media contributes not only to community development but also enriches broader academic and technological fields. By prioritizing equity in research, Indigenous communities are empowered to control and benefit from their intellectual and cultural contributions[Chen2024].

New Opportunities for new Indigenous Media Technology

Numerous innovative technologies and techniques could emerge from an ICCMIE, especially when grounded in the cultural practices and worldviews of indigenous communities in the Pacific Rim.

Creative computational media can serve as a powerful tool for the revitalization and reconnection of Indigenous cultural heritage. Digital storytelling platforms, such as video games, immersive technology, computational photography, and AI, enable the recording and dissemination of histories, languages, cultural narratives, and creative expression, helping Indigenous communities reconnect with their ancestral knowledge and ensuring they are passed onto future generations. See section **E.** for examples.

New Opportunities for Indigenous Media for Global Exchange

Indigenous media plays a vital role in fostering global cultural exchange by providing new avenues for sharing Indigenous cultures with a broader audience. Virtual cultural exchange, digital exhibitions, and immersive VR experiences allow Indigenous communities to promote their heritage while generating revenue. These virtual platforms enable Indigenous creatives to access global digital distribution channels, showcasing their work to a worldwide audience while forging strategic partnerships with tech companies and creative industries. Such collaborations promote equitable co-creation and ensure respect for Indigenous intellectual property, enhancing both cultural representation and economic benefits.

Additionally, organizations like the NSF can leverage their national and global platforms to highlight Indigenous Creative Computational Media, positioning it as a legitimate approach to engaging Indigenous communities. By doing so, they can help shift the global perception of Indigenous communities, recognizing them as key contributors to both cultural preservation and technological innovation.

E. Examples of New Creative Computational Media Technologies and Techniques that Could Emerge from an Indigenous Creative Computational Media Innovation Ecosystem

Several innovative technologies and techniques could emerge at the intersection of creative computational media and indigenous knowledge systems, especially when grounded in the cultural practices and worldviews of indigenous communities in the Pacific Rim. These projects underscore a key requirement for Indigenous communities: their interest in utilizing data, advanced imaging and audio capture, AI, and creative media to foster a holistic visceral understanding of the living world. At our workshop, we introduced a new term to describe this concept—Visceral Reality.

Artificial Intelligence

Culturally-Informed AI for Digital Storytelling

Example Technology: AI-driven narrative engines that incorporate Indigenous oral traditions, mythologies, and storytelling structures, as well as the ability to vocalize in indigenous languages.

Potential Technique: Algorithms can be developed to recognize and generate storytelling patterns unique to Indigenous cultures. These patterns might include branching narratives that follow non-linear timelines or involve communal storytelling, integrating multiple perspectives and voices. Oral traditions are also crucial in Indigenous communities, where storytelling is often a shared, dynamic process. However, current AI Text-to-Speech and Speech-to-Text technologies do not yet support Indigenous languages, limiting their utility for preserving and promoting these oral traditions. Addressing this gap in AI capabilities is critical for ensuring that Indigenous cultural expressions are accurately represented and sustained in digital platforms, as well as providing an opportunity for scientific innovation.

Generative Art Based on Ethnomathematics

Example Technology: Generative design tools that produce digital or physical art using algorithms based on Indigenous mathematical principles (e.g., Polynesian navigation, fractals in Pacific art- koru/fern).

Potential Technique: Artists could input traditional patterns, motifs, or cosmological principles into these tools to generate dynamic, evolving artworks that reflect their cultural worldview. The technology could be used to create anything from digital murals to fabric designs to virtual and physical art installations. This would stimulate research in the area of data physicalization [Citation Group C]- which centers on the creation of physical structures to give audiences a more visceral understanding of data and information.

Cultural AI Avatars and Digital Elders

Example Technology: AI-driven avatars that are trained to represent the wisdom and teachings of community elders, offering interactive, culturally aligned guidance and education.

Potential Technique: Avatars designed based on recorded teachings, stories, and wisdom of elders, combined with real-time language processing using Large Language Models to engage in dialogue with users. These avatars could be integrated into educational platforms, VR environments, or mobile apps, ensuring that traditional teachings remain accessible to future generations.

Immersive Technologies

Interactive Language Revitalization Tools with Mixed Media

Example Technology: Language learning apps and platforms that use mixed reality (AR/VR) combined with traditional oral storytelling and song to teach indigenous languages in context.

Potential Technique: Language lessons delivered in immersive cultural settings (e.g., a virtual village), where users engage in interactive dialogues, songs, and traditional narratives. These tools could also integrate voice recognition that adapts to linguistic nuances specific to indigenous languages.

Ancestral Knowledge Integrated Augmented Reality (AR) Applications

Example Technology: AR apps that overlay traditional ecological knowledge and cultural practices onto real-world landscapes.

Potential Technique: Users could scan physical environments (e.g., forests, rivers, sacred sites) with their smartphones or AR glasses to reveal cultural knowledge—such as plant uses, traditional land management techniques, or spiritual significance—based on location-specific data.

Virtual Reality (VR) Cultural Immersion Platforms

Example Technology: VR environments that faithfully recreate landscapes, cultural practice, and historical events for educational and cultural perpetuation purposes.

Potential Technique: Multi-sensory immersion where users not only see and hear but also "feel" traditional environments through haptic feedback devices that simulate textures or environmental conditions. These platforms could also support communal VR spaces where indigenous elders and youth can engage in traditional practices together, even if separated by distance.

Biocultural Restoration Platforms with Immersive Monitoring Tools

Example Technology: Platforms that use AR/VR and sensor networks to monitor and visualize biocultural restoration efforts, integrating cultural data with environmental metrics.

Potential Technique: Tools where users can "see" the impact of restoration projects—like the regrowth of culturally significant plants or the return of certain animal species—in real-time, guided by both ecological data and cultural narratives. Communities could use these tools to document, monitor, and communicate the success of restoration projects.

Data Physicalization with Traditional Aesthetic Forms

Example Technology: Tools for transforming complex environmental and cultural data into physical, tangible forms using traditional art and craft techniques.

Potential Technique: 3D-printed artifacts, textiles, computational thermoforming[Schuller2016], or carvings that represent data patterns—such as climate data, migration patterns, or agricultural cycles—using visual motifs from indigenous art forms. The physicalization could follow traditional crafting methods while being informed by computational data, creating new hybrid forms of cultural expression.

Re-designing Existing Technologies through Indigenous Lens

Indigenous Game Engines and Development Frameworks

Example Technology: Game engines or development kits designed with Indigenous cultural values at their core, emphasizing community, cooperation, and reciprocity rather than competition or resource extraction.

Potential Technique: These engines could include culturally aligned gameplay mechanics (e.g., circular time loops, cooperative problem-solving, resource-sharing mechanics) and support for incorporating indigenous languages, art, and symbolism into game design. These could be used to create games that educate while preserving ancestral knowledge and stories.

Decolonized Digital Archives with Dynamic Access Controls

Example Technology: Decentralized archives where indigenous communities control access to their cultural assets, deciding who can view, share, and interpret them.

Potential Technique: Smart contracts and dynamic access controls that allow communities to grant or revoke permissions in real-time. This ensures that sensitive cultural information remains protected while allowing controlled public engagement, ensuring that knowledge is shared according to traditional protocols.

Community-Driven Immersive Geospatial Platforms

Example Technology: Geospatial visualization tools that integrate traditional land-use knowledge with modern GIS data, enabling communities to create 3D maps or simulations that showcase the interconnectedness of people, place, and environment. The Atlas of Drowned Towns [Shuller2016] is an excellent example of this.

Potential Technique: Platforms where Indigenous knowledge holders contribute layers of data to create living maps that evolve over time, tracking ecological changes, cultural events, and stewardship practices. The maps could be used for land management, education, and advocacy.

Hybrid Knowledge Systems in Interactive Digital Interfaces

Example Technology: Interfaces that blend indigenous and scientific knowledge systems, allowing users to explore complex issues like climate change, food sovereignty, or biodiversity through both worldviews.

Potential Technique: Interactive dashboards or storytelling platforms where users toggle between scientific data (e.g., satellite imagery, analytics) and traditional knowledge narratives, with each informing the other. For example, a user might explore how seasonal cycles are understood through both climate science and indigenous ecological calendars.

F. Recommendations

As the workshop participants have articulated, Indigenous practices represent a corpus of bio-centric scientific observation refined over millennia in a specific geography which optimizes for integrating human basic societal needs into the carrying capacity of regional ecosystems. They have also noted that Indigenous communities, therefore, represent an ecosystem of innovation, whose barriers to participation in broader innovation conversations are not due to any merit of their work, but instead a lack of meaningful framework to access broader fiscal and political capital.

Underpinning all of the following recommendations should be the comprehensive goal of positioning Indigenous communities as spaces of investment towards the co-design, and co-production of contemporary innovation outputs. This commitment to investment ensures that equity is not reflected as equity in inclusion, but equity as the restoration of agency.

To align with the National Science Foundation's (NSF) goals of advancing research, ensuring inclusivity, and leading global innovation, the following seven recommendations focus on providing a holistic approach to investing in the capacity of Indigenous community organizations to finance, develop, scale, and sustain the proposed ICCMIE needed to establish a vibrant, community driven ecosystem of innovation.

Funding Recommendations

1. Invest in Indigenous Creative Computational Media Innovation Hubs

Just as astronomers rely on large telescopes, oceanographers depend on ocean science vessels, and physicists require the Large Hadron Collider, Indigenous communities need culturally-driven innovation hubs—laboratories for conducting research and development at the intersection of Indigenous Knowledge and Creative Computational Media. These hubs are the equivalent of these scientific instruments, serving as essential spaces for advancing innovation in their respective fields.

By integrating traditional knowledge with advanced technologies, these hubs would foster sustainable, culturally aligned innovation and capacity building. Ensuring access to robust cyberinfrastructure in Indigenous communities is crucial for their participation in broader digital economies and innovation ecosystems. Embedding Indigenous knowledge into NSF-supported initiatives also ensures a more inclusive and culturally grounded approach to technology development, contributing to sustainability and resilience. By prioritizing cyberinfrastructure development and funding sustainable, community-driven projects, we can help Indigenous communities create adaptable, self-sustaining solutions that balance cultural, economic, and environmental needs, ensuring lasting benefits for future generations.

2. Support Indigenous-Centered Research and Development

Fund interdisciplinary research projects that explore the intersection of traditional knowledge, creative computational media, and technological innovation. These initiatives should be led and/or co-produced by indigenous scholars and community members. Such research can produce new methodologies and scalable models that honor cultural sovereignty while advancing digital media, AI, and immersive technologies.

Support pilot projects that demonstrate the economic and cultural benefits of creative computational media in indigenous communities. These projects should include robust evaluation frameworks, providing models for scaling successful approaches in areas like cultural tourism and game development.

3. Develop Education and Workforce Programs

Create STEAM programs that blend indigenous knowledge systems with creative computational media. Offering culturally relevant curricula and career pathways in creative industries will inspire and prepare indigenous youth to engage in this field, driving both cultural preservation and economic growth. Workforce initiatives should include internships, fellowships, and mentorship opportunities.

4. Support Indigenous Entrepreneurship and Commercialization

Provide grants, business development programs, and commercialization support for indigenous entrepreneurs in creative computational media. Targeted programs offering training in business management, marketing, and global market access can build resilient indigenous-led startups and businesses, contributing to the broader innovation ecosystem.

Policy Recommendations

5. Promote Digital Sovereignty and Data Governance

Fund projects that develop digital tools where indigenous communities maintain control over their cultural and intellectual property. Support for indigenous-led data governance (through frameworks like the CARE principles [Citation Group D] that ensures that cultural assets are used and shared according to community values, fostering long-term trust and sustainability.

6. Advocate for Indigenous Sensitive Review Criteria for Intellectual Merit and Broader Impact

Overall, the grant application processes must be made more accessible and supportive of indigenous and community-based organizations. NSF's review process, which focuses on "Intellectual Merit" and "Broader Impact," could benefit from being reinterpreted to include indigenous practices and values. This includes rethinking how practices like learning from the land ('āina) should be viewed as part of intellectual merit rather than just broader impact. Also, there needs to be a process of including and validating applicants and reviewers from indigenous communities who do not hold PhDs, but are leaders in their own communities.

International Programming

7. Foster Collaborative Networks Across the Broader Pacific Rim

Facilitate cross-border partnerships among indigenous communities, academic institutions, and technology firms. Collaborative networks can enhance knowledge sharing, strengthen cultural ties, and scale successful models across multiple communities. As an example, Canada's USD17 million Abundant Intelligences [Abundant] project supports indigenous hubs focused on integrating Artificial Intelligence with Indigenous Knowledge. Hawai'i's Create(x) at University of Hawai'i West Oahu is one of the funded hubs. This project required a cost-sharing commitment from the groups it funds. Notably, the Canadian government allows U.S. federal funds to count toward this cost share. However, NSF does not have a similar provision in place, and therefore the use of U.S. federal funds for cost share is considered unallowable under NSF guidelines. This discrepancy can create challenges for U.S. groups seeking to collaborate on international projects like Abundant Intelligence.

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*Changes and evolution

No significant changes were made to the original proposal.

*Recruitment strategy

The University of Hawai'i's academic year starts on August 26, necessitating that our workshop be held at least a week before the semester commenced. Consequently, the tight timeline precluded the possibility of an open call for participants and a subsequent review process. Therefore, we relied on the organizers to personally invite experts in relevant fields. Although we targeted many creative media practitioners in

companies such as Pixar and Disney, their limited availability and the requirement to obtain permissions from their employers led to a high number of declines.

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Regional Opportunities / Follow-up activities

The University of Hawaiʻi is part of an international group of researchers and Indigenous practitioners that was awarded a $23-million (Canadian and approximately $17-million U.S.) grant from Canada's New Frontiers in Research Fund to work on improving artificial intelligence (AI) through Indigenous knowledge.

The project, "Abundant Intelligences: Expanding Artificial Intelligence through Indigenous Knowledge Systems," is Indigenous-led and involves 37 co-investigators and collaborators from eight universities and 12 Indigenous community-based organizations from Canada, the United States and New Zealand.

The teams are coalesced in locally rooted "pods" to collaborate with Indigenous communities. In this way, each team will learn from, and alongside, Indigenous knowledge keepers to bring novel perspectives to transforming AI.

The network of Indigenous Knowledge pods include: University of Hawai'i West Oahu; Concordia University, Montreal; Onkwehonwe Research Environment, Lethbridge U, AB; Indigenous Design Innovation Aotearoa, Wellington; Sorginak Media Lab, Washington State U, WA; Aabijijiwan New Media Lab, U of Winnipeg, M; and the Indigenous Futures Institute, UC San Diego. Partner organizations Mila Quebec AI Institute, UdM's Cognitive & Computational Neuroscience Lab, IVADO Institut de valorisation des données, and MIT's Center for Advanced Virtuality.

Abundant Intelligence will be holding a Aotearoa workshop during the week of Nov 9. Some participants in this ICC workshop have expressed interest in participating in the Abundant Intelligence workshops.

Other Notes

Anything else to report? Up to 500 words, option for "nothing to report".

Nothing to report.