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Todd J.B. Blayone* and Olena Mykhailenko

Using Digital Technologies for Indigenous Sociocultural Advancement in an Era of AI: A Systematic Critical Synthesis

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Abstract: Indigenous cultural resurgence parallels generative AI emergence. This article synthesizes digital technology projects for Indigenous sociocultural advancement. It analyzes 69 studies in five continents through a bifocal critical apparatus. The first lens uses activity theory to explore project ecologies comprised of peoples, objectives, places, technologies, and tensions. The second lens reveals ideopolitical framing patterns as studies are strategically positioned at the interface of Euro-Western and Indigenous cultures. Eight project types, developed by and for Indigenous peoples, are identified. Although consumer technologies predominate, many complex IT assemblages are attested. However, technological complexity often requires "outsider" experts, which limits local control over processes, data, and outcomes. The sampled studies highlight three ideopolitical frames: cultural bridging, countering Euro-Western dominance, and technical problem-solving. The foregrounded political themes are digital empowerment, data sovereignty, identity expression, and online activism. This study critically organizes underexplored research and charts new pathways for exploring digital technologies, culture, and Indigeneity.

Keywords: digital technology; cultural resurgence; indigenous; sociocultural advancement; cultural digitization

1 Introduction

In recent decades, Indigenous peoples have pursued cultural reclamation through grassroots activism, engagements with the United Nations, and legal action in settler-dominated nations (United Nations 2023). These efforts have occurred alongside the proliferation of Euro-Western information and communication technologies (ICT) which are increasingly incorporating algorithms showing signs of general intelligence (Bubeck et al. 2023). Academics in several domains are bridging these developments by instigating and investigating strategic uses of ICT and artificial intelligence (AI) to support Indigenous sociocultural resurgence.

The contexts of this research are diverse and strewn with logistical and political challenges. The United Nations (2023) estimates the global population of Indigenous peoples to exceed 370 million, representing over 5,000 distinct cultures in every continent except Antarctica, and comprising 5 % of the world's population. However, this convenient statistical reduction only begins to capture the full spectrum of Indigenous experience. Indigenous peoples may live in remote communities or thrive as members of urban diasporas. Their diverse lifestyles, values, and material cultures plot on trajectories that predate or coincide with Euro-Western migration, settlement, and colonization. Some Indigenous groups express concern about the encroachment of "outsider" technologies and the erosion of traditional cultural practices (Bala and Tan 2021; Rosa 2022). Other groups enthusiastically deploy high-tech systems to meet social, informational, and governance objectives (Métis Nation of Ontario 2021). Some Indigenous peoples even express openness to "kinship relations" with non-human entities (Morford and Ansloos 2021), which aligns with emerging forms of human-machine symbiosis (Gladden 2019). Although Indigenous collectives tend to comprise non-dominant populations within settler states (Daes 2008), Indigenous individuals often thrive as social media influencers, IT specialists, and cyber activists (Carlson and Frazer 2021).

During a twenty-month fellowship at a Canadian university, the first author advanced a transnational program of technology research (Blayone 2019; Blayone et al. 2020; Blayone et al. 2018; Blayone and Van Oostveen 2020; Mykhailenko et al. 2020) through technical experimentation and interdisciplinary reading, including human-machineelations, Indigenous studies, generative AI and cultural analysis. One notable thematic cluster within a research database

***Corresponding author: Todd J.B. Blayone**, York University, Toronto, Canada, E-mail: todd.blayone@ontariotechu.net. https://orcid.org/0000-0001-6965-7033
Olena Mykhailenko, Goethe-Institute, Kyiv, Ukraine. https://orcid.org/0000-0001-6987-7079

addressed uses of digital technologies for Indigenous sociocultural advancement. This cluster offered a conceptual link between Indigenous resurgence and the emergence of human-level machine intelligence (Goertzel 2007), offering fertile ground for synthesis.

The authors began by reviewing extensive research notes in an Obsidian knowledge base and formulating exploratory questions to construct a robust theoretical perspective:

- What are the Indigenous cultural advancement foci of published projects?
- What peoples, places, and digital technologies are involved?
- What are the identities and cultural commitments of the actors?
- What digital technologies and machine intelligence are deployed?
- What challenges arise when academic researchers, IT specialists, and Indigenous community representatives collaborate?
- How do researchers relate their studies to Indigenous ways of being and knowing?
- What political issues emerge in the digitization of Indigenous culture?
- Do academic interventions yield measurable benefits for Indigenous peoples, and are these recognized by the intended beneficiaries?

These questions spanned technological, sociocultural, and ideopolitical concerns, underscoring the need for a transdisciplinary approach. The authors recognized that Indigenous-engaged projects operate at a fragile interface between dominant Western sociocultural systems and historically suppressed worldviews. Thus, mapping the "state of knowledge" required more than organizing goals, methods, and outcomes – it also demanded critical interrogation of systemic tensions, the subtle politics of cultural digitization, and the discursive strategies shaping project reporting.

Consistent with this research agenda, Section 2 defines our multi-perspectival conceptual lens delineating the inquiry and structuring the formal research questions (RQs) in Section 3. Section 4 presents a precise methodological statement grounded in systematic review repertoires. Section 5 organizes findings sequentially by RQ, integrating visualizations for clarity. Finally, Section 6 discusses novel insights, acknowledges limitations, and outlines directions for future research.

2 Conceptual Lens

A bifocal conceptual lens, as visualized in Figure 1, was constructed to formulate research questions and guide a critical synthesis. This lens appropriated (a) cultural historical activity theory (Kaptelinin and Nardi 2012) to analyze ecological and operational characteristics of techno-cultural projects by and for Indigenous peoples, and (b) framing theory (Chong and Druckman 2007) to organize ideopolitical patterns in the academic reporting of these projects. With sensitivity to social, technical, and political dynamics of cross-cultural interaction and research reporting, this apparatus lends itself to orchestrating a holistic critical synthesis of the sampled literature.

2.1 Cultural Historical Activity Theory

Cultural-historical activity theory (CHAT) originates from an early Soviet research program exploring a human subject (S), mediating means (M) (e.g., physical artifacts and cognitive "tools"), and a motivating object (O) (Vygotsky 1978). The primary goal was to investigate the psychological processes by which human cognitive schemata are (re)structured by techno-cultural mediation. The concept of "activity" was introduced as a minimal context for analyzing S-M-O scenarios (Leontiev 2005).

Subsequently, Western scholars developed CHAT in two synergistic directions. One direction, rooted in human-computer interaction (HCI) research, focused on individual subjects engaged in technology-mediated activities (Kaptelinin and Nardi 2012). This perspective emphasized human agency and effective IT mediation as critical factors in achieving one's goals. The other direction, rooted in the developmental work research of Yrjö Engeström (2000), expanded the social context of activity. Engeström's activity system incorporated situated ensembles of humans and mediating technologies in goal-driven assemblages that produce outcomes and *tensions*.

Three directing insights are distilled from this research tradition, which is elaborated in detail elsewhere (Blayone 2019; Kaptelinin and Nardi 2012). These insights align with key themes in Indigenous studies research and are used to formulate the first two of four RQs.

(1) Orchestrated systems: Activities are conducted within orchestrated ecologies of human entities, mediating technologies, processual repertoires, and relational dynamics, forming socially bounded systems. These systems are driven by objectives (including intentions, purposes, and strategies) and mediated by operational dynamics and cultural protocols. Viewing activities as contextually rooted ecosystems aligns with Indigenous place-based epistemologies (de Mori 2016).

(2) Control dynamics: Entities in activity systems express agency – the ability to act towards a goal (Kaptelinin and Nardi 2012). Human agency contributes to a sense of self-efficacy, reinforcing positive functioning

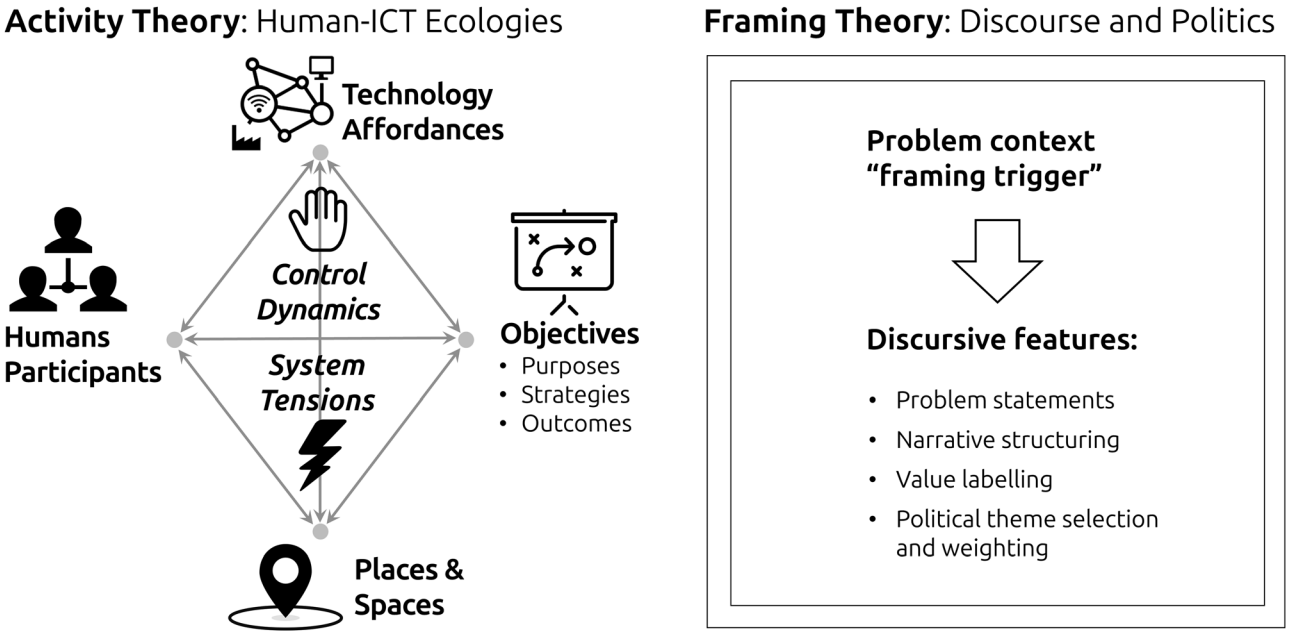

Figure 1: Visualization of bifocal theoretical lens guiding research questions.

(Bandura 2006). Hinzo and Clark (2019) introduce "survivance," a portmanteau of "survival" and "resistance," as a distinct aspect of Indigenous digital agency (Lewis 2023). Self-determined agency, or taking action aligned with one's skills and values free from coercion, is highly valued by humans (Deci and Ryan 2000). Self-determination is an individual and collective aspiration of Indigenous peoples in settler states (MacDonald 2023). Romero et al. (2016) extend agency to intelligent machines, repositioning humans among non-human entities in a manner aligned with Indigenous kinship ontologies (Lewis 2023).

(3) Tensions: Activity systems produce both outcomes and tensions. The latter includes, for example, human power struggles and contested perspectives on technology, ownership, or undergirding values. Projects involving Indigenous peoples may invoke tensions rooted in experiences of colonization and differences between Western and Indigenous onto-epistemologies (Grincheva 2013).

2.2 Framing Theory

Indigenous research operates in a delicate political space, where shared "ways of being and knowing" must be negotiated, and tragic histories of Indigenous-settler relations cast their shadow (Jones 2011; MacDonald 2019). Framing theory (Chong and Druckman 2007) addresses ideopolitical patterns in research reporting. Two insights are appropriated from this theory, informing the latter two of four RQs.

(1) Framing: To "frame" communication is to select facets of a critical issue and position them to promote a specific problem definition, interpretive structure, moral stance, or remedy. Frames generally reference weighted beliefs from memory rather than evidence and argumentation (Nelson, Oxley, and Clawson 1997). In this sense, they are deeply entwined with the cultural heritage of researchers and authors.

(2) Triggering and discourse: Within IT research involving Indigenous peoples, framing orientations are triggered as authors position their projects in relation to Euro-Western and Indigenous epistemologies, ontologies, and cultural protocols. Frames reveal themselves in discourse (Gee 2011), including uses of pronouns (e.g., "us" and "them"), narrative structures, value labels, and political themes.

3 Research Questions

Four RQs, two guided by activity theory and two by framing theory, represent the analytical foci of this study.

RQ1. What are the system ecologies of the human-IT activities reported in the sampled research?

RQ2. How are the reported activities orchestrated, and what systemic tensions emerge?

RQ3. What framing orientations are used to describe projects operating at the intersection of Euro-Western and Indigenous cultures?

RQ4. What issues of research politics are foregrounded in the selected studies?

4 Methodology

To address the RQs, a critical synthesis was conducted via systematic (a) literature selection and reduction and (b) matrix generation and pattern analysis (Paré et al. 2015; Torraco 2005), as highlighted in Figure 2.

4.1 Data Selection and Reduction

Clarivate's Web of Science (WoS) Core Collection functioned as a primary data source based on established best practices (Gusenbauer and Haddaway 2020), high-quality metadata, a strong bibliometric toolset, and tight integration with Endnote. The formal WoS search was initiated with a Boolean string to which several filters were added. The search was limited to peer-reviewed articles and conference papers published from 2019. Highly specialized engineering, medical, and natural science publications were excluded from the included search domains. The formal search returned 474 unique bibliographic records with rich and consistent metadata. These records were imported into Endnote for data reduction and full-text downloading in three phases. (Google Scholar results were used for scoping only, owing to their relatively inconsistent and incomplete metadata. Relevant results from other quality databases such as Scopus were found to duplicate those in the systematically produced WoS results).

In the first data-reduction phase, abstracts and metadata were reviewed in Endnote. Excluded articles were (a) literature reviews, (b) those not written in English, (c) a largely replicated study by the same author (or authors) of an included study, and (d) those lacking a focus on IT and Indigenous peoples. In this way, the article set was reduced to 156 items. In the second data-reduction phase, full-text PDFs were imported into Endnote, reviewed, and divided into eight activity types. During this process, three emergent exclusion criteria were identified as (a) using "AI" as an abbreviation for American Indian, and not addressing an IT project; (b) focusing exclusively on the COVID-19 pandemic or methodological issues; or (c) positioning "Indigenous" as one of many sociodemographic variables. The application of these criteria reduced the set to 141 items.

Finally, it became apparent that thematic saturation was achieved with 10 articles per activity type. Thus, in the last reduction phase, four (of eight) article groupings that exceeded this count were reduced to 10 through random selection. Thus, the total sample was reduced to a manageable set (n = 69). The sampled articles presented in tabular form (with selected contextual data) as an Appendix.

4.2 Data Analysis and Findings Production

Managing one category at a time, the analytical protocol involved close readings, producing thematic and discourse-

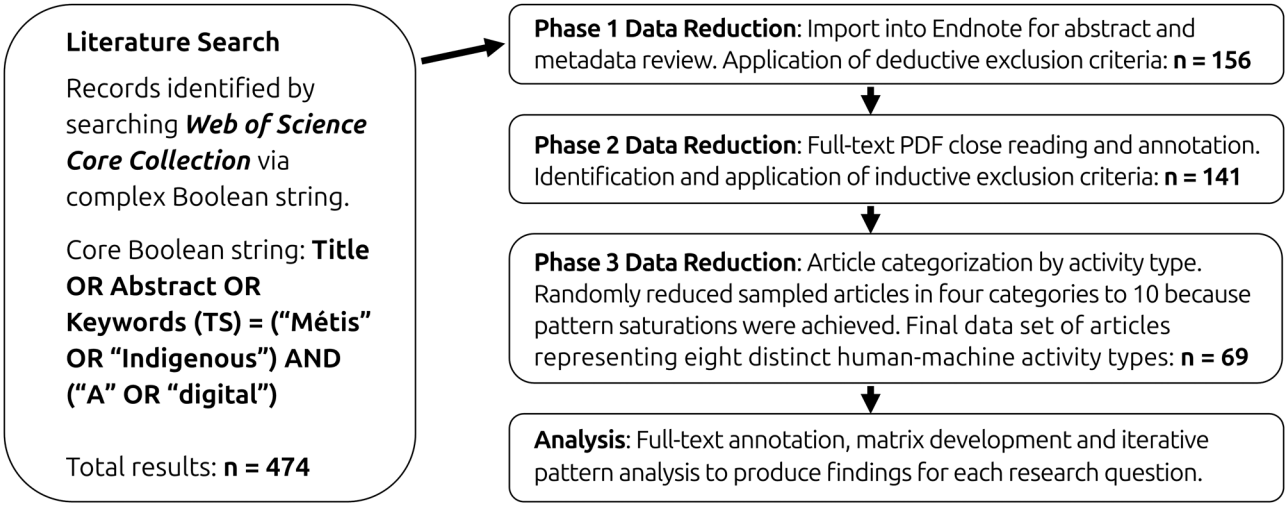

Figure 2: Flow diagram showing the systematic methodological workflow.

related annotations, and inputting extracted and paraphrased data into a matrix to address the four RQs (Klopper, Lubbe, and Rugbeer 2007). Each article was placed in a row. Column headers addressed major themes (aligned with the RQs) and emergent metadata. The completed analytical matrix consisted of over 3,000 data points. Findings for each RQ were produced through iterative textual reduction, tagging, sorting, and identifying semantic patterns in relevant columns.

5 Findings

Findings are organized sequentially by RQ. Article-level frequency counts and percentages are provided to highlight thematic distributions across the dataset. (These quantitative reductions sometimes hide interpretive nuances and discursive intensities within single articles).

5.1 RQ1. Ecology of Activity

The first RQ requires an accounting of human participants, places, IT deployments, and activity types. These elements comprise ecosystems of human-machine activities in the sampled studies. Figure 3 presents key highlights from RQ1 findings.

5.1.1 Human Participants

Participating human agents are primarily academic researchers and Indigenous collaborators. Academic researchers represent universities in Canada, Australia, the United States and New Zealand (n = 54). Twenty-seven studies include explicit identity markers. Of these, 28 % of the studies identify at least one Indigenous author (n = 15) and 22 % acknowledge non-Indigenous authorship (n = 12). Most studies (n = 42) avoid explicit cultural identifiers in authors' descriptions. However, attentive readers can sometimes draw identity inferences from the discourse (e.g., use of pronouns).

Studies address Indigenous peoples in six configurations. Almost half (n = 30) reference Indigenous nations or communities (e.g., First Nation Community of Waywayseecappo in rural Manitoba, Canada; Wounaan people of Panama and Columbia; Zapotec diasporic community in the United States; Māori throughout the world). Some studies (n = 19) address mixed regional groupings (e.g., Indigenous peoples of central Australia, North America, or Bangladesh). Other studies address Indigenous artists or professionals as individuals (n = 7), Indigenous peoples belonging to a gender or sexual-orientation subgroup (n = 6), or historic peoples (n = 2). A few studies reference "Indigenous peoples" as a general identity collective (n = 5).

5.1.2 Places and Spaces

"Place" is a central construct in Indigenous culture (Morford and Ansloos 2021). Despite linkages between dominant cartographic practices and colonial epistemologies (Briggs et al. 2020; Broadhead 2020), English-language place names are favoured in the research. Thus, at the macro level, the sampled studies span 19 countries on five continents (North America, Eastern and Western Europe, Asia, Africa, and

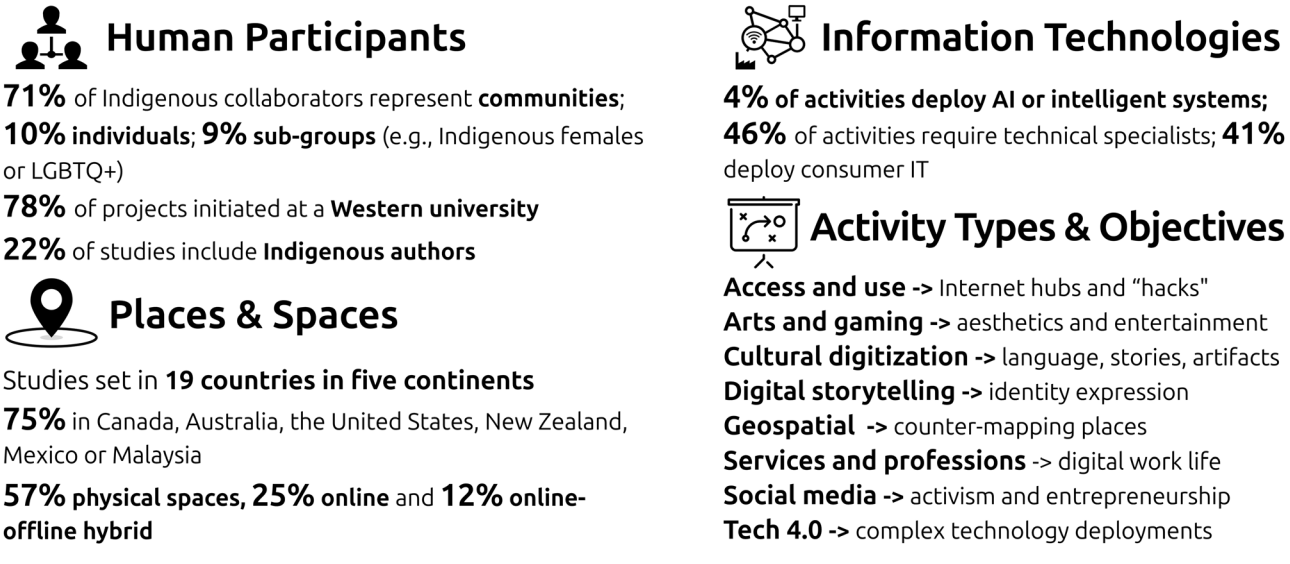

Figure 3: Key highlights of activity ecologies.

Oceania). Over 75 % of reported activities were conducted in six countries: Canada (n = 16), Australia (n = 14), United States (n = 13), New Zealand (n = 8), Mexico (n = 3), and Malaysia (n = 2). Indigenous names for Canada, New Zealand, and Mexico (namely, "Turtle Island," *Aotearoa*, and *Oaxaca*) are only occasionally used (n = 6).

At the micro-level, most studies are associated with physical locales (n = 39). These include large regions (e.g., Australia's Northern Territory), single communities (e.g., Wasauksing First Nation community, Ontario, Canada) or places within a community (e.g., a school or youth center). Other studies address activity in social media platforms or websites (n = 17). A few studies reference hybrid spaces manifested by Augmented Reality (AR), Virtual Reality (VR), or online-offline activism (n = 8). A few are not place-specific (n = 4).

5.1.3 Information Technologies

Technology assemblages vary greatly and include:

- Consumer hardware and software, including desktop computers, mobile devices, social platforms, and productivity applications (n = 28),
- Specialized applications requiring IT training or programming knowledge (n = 20),
- Sophisticated hardware deployments such as networking equipment, geographical information systems (GIS), and AR or VR platforms (n = 12),
- and smart technologies or AI (n = 3).

In some cases, facilitating technologies are undisclosed (n = 6). As deployments become more complex, there is increasing dependence on academic and IT specialists.

5.1.4 Activity Types

Projects in the sampled investigations were reduced to eight types. Some types emphasize a class of affording technologies, and others highlight a dominant objective, which may incorporate diverse IT assemblages. Listed in alphabetical order, these activity types were labelled: *Access and Use* (n = 7); *Arts and Gaming* (n = 6); *Cultural Digitization* (n = 10); *Digital Storytelling* (n = 10); *Geospatial Mapping* (n = 8); *Services and Professions* (n = 8); *Social Media* (n = 10); and *Tech 4.0* (n = 10).

5.2 RQ2. Activity System Orchestration

The second research question addresses orchestration characteristics of each activity type identified, including motivating objectives, technology choices, control dynamics, and system tensions. Table 1 organizes key highlights from the detailed findings.

5.2.1 Access and Use

Set mostly in remote communities, activities in this category highlight Indigenous agency and problem-solving. For example, community technology leaders in Malaysia and Mexico, who are primarily male, collaborate with "outsiders" to maintain telecentres and ad hoc networks, providing communal Internet access (Bala and Tan 2021; Rosa 2022). In other contexts where Internet access exists, leaders promote using mobile devices for community cohesion, political expression, and economic development (Hasan, Bao, and Miah 2022; Horn and Gifford 2022; Rivera and Rojas 2021; Young 2019).

These activities generate two classes of tensions. First, conflicts with external entities can arise when do-it-yourself networks break the rules of commercial service providers (Rosa 2022). Second, some community members resist IT adoption, fearing that it (a) promotes Western urbanized lifestyles, (b) reduces the time spent participating in community gatherings and land-based learning, (c) provides undue advantages to younger people, and (d) makes communities dependent on technology "outsiders" (Bala and Tan 2021). In one setting, almost 20 % of those interviewed feared that IT adoption would cause a youth exodus from the village (Bala and Tan 2021).

5.2.2 Arts and Gaming

This category features Indigenous cultural *producers*, including an Ecuadorian YouTube musician (Aguilo 2020), teams of Sámi and Māori game designers (Nijdam 2023; Reihana, Taura, and Harcourt 2019), mixed Indigenous artists exhibiting in an online exhibition (Vett 2019), and Zapotec producers of YouTube "road trip" videos (Ruiz 2022). The technology assemblages are generally off-the-shelf computers, design applications, and online media platforms. One outlying study adopts a digital marketing perspective, offering a (settler) proposal to redesign Indigenous art centre websites in Australia's Northern Territory (Vett 2019).

This category highlights Indigenous creative agency. However, the reception of resulting cultural artifacts varies, and tensions can emerge between artists and audiences. For example, Aguilo (2020) introduces the case of Delfín Quishpe. His YouTube music video ("Torres gemelas") went viral in the late 2000s, reaching millions of views. However, the artist's popularity was mainly driven by ridicule in the user comments. Aguilo (2020) addresses this tension through the lens of cultural kitsch, "symbolic violence" and a dark history of class-based judgments of artistic value. In a second case, Ruiz (2022) explores road trip videos depicting journeys to pueblos in

Table 1: Key orchestration highlights by activity type.

Activity	Purpose(s)	Tech & control	Tensions
Access and Use	Acquire and promote community internet access and mobile device use	Telecentres and ad hoc network infrastructures with prominent indigenous creative agency	(a) Connectivity solutions may bypass ISP protocols; (b) Elder resistance to culturally destructive "urban" or "outsider" technologies
Arts and Gaming	Produce games, videos, and art objects foregrounding indigenous identities	Consumer-level design applications prominent indigenous self-determination and culturally inspired activity	(a) Mismatch between producer objectives and audience reception; (b) technology affordances and creative outputs mask harsh social realities
Cultural Digitalization	Preserve and share material culture, respecting indigenous protocols	Complex IT assemblages and data management protocols create a significant dependence on information science and IT specialists	Misalignments between academic preservation goals and the expressed needs and interests of indigenous participants
Digital Storytelling	Produce culturally affirmative narratives that promote indigenous identity and push back against dominant western values	Mostly undocumented technologies deployed for choreographed activism and education workshops; some unchoreographed indigenous storytelling	(a) "Erasure" of technological affordances and absence of generative AI platforms; (b) claims of positive outcomes are often anecdotal
Geospatial Mapping	Produce maps that foreground indigenous experience, knowledge, and "sense of place"	Complex technology assemblages support expert-led cartographic activism and indigenous counter-mapping	Tensions between stated decolonization goals and latent colonial dynamics of expert-led projects
Services and Professions	Showcase indigenous IT, journalism, and educational professionals, some of whom achieve success with IT and some of whom face challenges	Mixed IT complexity with prominent examples of indigenous creative agency (bounded by professional contexts)	(a) Indigenous IT professionals report professional success and opportunities to express their culture; (b) those with poor digital skills report struggles using emerging IT systems
Social Media	Pursue collective and individual, political, entrepreneurial, social, identity, and communication goals	Emphasis on self-determined uses of Facebook groups and other social media affordances	(a) Successful social media activity favors the technically savvy; (b) "hashtag" campaigns have little impact on public policy, and may be coopted by celebrity allies
Tech 4.0	Deploy intelligent algorithms and AI for indigenous cultural expression	Complex technology and human resource requirements with some indigenous representation	The underrepresentation of indigenous IT professionals and engineers can lead to a colonial dynamic and "settler-splaining"

Mexico. At first glance, these ungarnished depictions of vehicular travel to Zapotec communities appear mundane. However, looking closer, these artifacts offer proxy homecoming experiences ("mobile postcards") for an undocumented diaspora landlocked in the United States (Ruiz 2022).

5.2.3 Cultural Digitalization

Digitalization projects involve curating, preserving, and promoting cultural phenomena, including oral and textual traditions (Bow 2019; Alvarado, Barriente, and Bigelow 2021; Broadwell et al. 2020; Langdon 2020), biocultural heritage (Carney et al. 2022), and material artifacts (Ellis, Macdonald, and Almeida 2022). IT deployments can become quite complex in facilitating artifact imaging, database design, item cataloging, or markup (using Indigenous-specific taxonomies), and the development of online interfaces. Consequently, these projects are primarily initiated and led by information scientists and technical specialists, with Indigenous people functioning as collaborators and end users.

The primary tension in this category is between noble academic intentions and Indigenous communities' interests and cultural preservation strategies. Bow (2019) worries that expert-led digitization projects may have re-colonizing effects, and the digital archives produced by specialists may not be valued and sustained by the communities they intend to serve. She was confronted with a misalignment between her project's outcome (a Living Archive website of rare Australian Indigenous texts) and the disinterested attitude of a community elder (Bow 2019). Similarly, Kelly and Taffe (2022) document their failure to complete a digital museum project in the Kelabit Highlands of Borneo, Malaysia, owing to a challenging environment and the underdeveloped digital skills of Indigenous collaborators. The Kelabit

community eventually abandoned the idea of digital archiving. (Assessing performance outcomes of projects is difficult because researchers generally fail to report usage statistics from the communities they intend to serve.).

An outlier in this expert-driven category is a report on the cultural preservation practices of an Indigenous village in central Australia (Vaarzon-Morel, Barwick, and Green 2021). In this case, the impetus for cultural digitization stemmed from the community. The authors observed how Indigenous peoples addressed their archival needs using mobile phones, low-tech devices (e.g., USB sticks), and social media platforms. These self-governed efforts reinforced collective self-determination, allowing conflicts to arise as community members expressed different attitudes toward IT, data ownership, and appropriate uses of cultural materials.

Importantly, expert-led projects can sometimes produce unexpected benefits. For example, an almost 50-year-long effort of collecting and digitizing audio recordings preserving the social life and oral traditions of the Siona in Putumayo, Columbia, was caught up in collaboration breakdowns, misunderstandings, inter-community conflict, and the intrigues of shamans (Langdon 2020). However, the researcher's years of labour and endless dedication were rewarded when she received an unexpected call from community leaders asking her to explain the meaning of "their term for well-being (*huajë*) and its relation to the term for 'Mother Earth'" (Langdon 2020, 146). This opinion was requested to support the community's legal battle to preserve their lands.

5.2.4 Digital Storytelling

Digital storytelling features two system configurations. The first involves structured workshops choreographed by experts for small groups in an Indigenous community or institutional setting. The second showcases the self-directed activities of individual Indigenous storytellers and artists. In both cases, autobiography and identity expression shape the narrative structures of media artifacts. A dominant collective theme in choreographed settings involves "pushing back" against hegemonic discourses and colonial memories (Rice et al. 2022). The reported outcomes of both storytelling configurations include: (a) engaging with Indigenous modes of knowledge production (Peña et al. 2021); (b) reactivating Indigenous identity (Sanchez-Pimienta, Masuda, and M'Wikwedong Indigenous Friendship Centre 2021) and memory (Chazan and Cole 2022); (c) cultural continuance (Cox 2022) and generational bridging (Hausknecht et al. 2021); (d) engaging with landscapes (Marques, McIntosh, and Carson 2019); and (e) developing traversal digital skills (Loebach et al. 2019). However, these reported benefits are often anecdotal.

The technology-use repertoires of storytellers go mostly unreported, with three exceptions. Cordes (2021) advocates for sophisticated GIS assemblages for (re)telling stories of the Rogue River War. Marques, McIntosh, and Carson (2019) design an AR application to retell the stories of Māori cultural landscapes and values. As a theoretical contribution, Loebach et al. (2019) explore how digital technologies *afford* the reshaping of oral storytelling.

The "erasure of the machine" in most storytelling accounts suggests a tension between traditional cultural production systems and emerging forms of human-machine partnering. The traditional view places the human agent in control and diminishes the role of tools and technologies in the creative process. At this historical moment, however, cultural producers increasingly share creative control with agential tools or "intelligent" entities (Guzman and Lewis 2019; C. Zhang et al. 2023). For example, transformer-based large-language models (LLMs) – a dominant form of generative AI – are transforming the traditional creative workflows of professional designers, musicians, and filmmakers (GlobalData Thematic Intelligence 2023; J. Nelson 2023; Othen 2023).

5.2.5 Geospatial Mapping

Indigenous peoples often link land-based relations and group identity (Morford and Ansloos 2021). De Mori (2016) argues that Indigenous peoples synchronize their lives with regenerative environmental cycles. Plant, animal, and mineral entities are "kin" rather than raw materials. Giving names and meaning to places creates original knowledge structures that often conflict with Western cartographic practices. Therefore, researchers are pursuing digital (re) mapping projects based on Indigenous knowledge. Such projects routinely deploy GIS assemblages with variations in constituent subsystems and levels of automation (Meisel et al. 2021; Briggs et al. 2020; Mamontova and Klyachko 2022).

Activities in this cluster are variously characterized as "counter-mapping" (Syme 2020), "community-engaged mapping" (Mamontova and Klyachko 2022), "decolonial mapping" (McGurk and Caquard 2020), and "cartographic activism" (Miner 2022). The technical challenge is to produce and visualize reliable source data aligned with Indigenous epistemologies. This data includes, for example, GPS coordinates for traditional territories, reservation allotments, cross-border communities, and (last known) locations of missing Indigenous persons. Occasionally, data is collected by Indigenous peoples themselves. However, in this category, Indigenous participants generally have limited control over project scope, technologies, and procedures (McGurk and Caquard 2020).

Only one lead author in this cluster identifies as Indigenous. However, most studies find fault with mainstream

mapping practices and the epistemologies on which they are based. Indeed, with few exceptions (Meisel et al. 2021), this category promotes an ideological discourse of righteous indignation. One settler scholar even conflates Israel's land settlement practices with the "erasure" of Mi'kmaq territories in Canada, citing Canadian taxpayer and government complicity (Broadhead 2020).

The primary tension in this category relates to the question: To what extent can academic remapping projects be Indigenized and decolonized? McGurk and Caquard (2020) systematically assess control parameters of Indigenous cartographic projects related to process, scope, framing, and technology deployment. They conclude that although some colonial dynamics can be mitigated (e.g., by sourcing data collection to Indigenous communities), academic counter-mapping is never inherently decolonial. As a potential mitigation, Syme (2020) proposes that mapping algorithms be co-designed with Indigenous elders "in spaces of deep equity" (1117). However, to what extent Indigenous peoples can trust outside experts to (re)engineer their land-based knowledge reliably remains an open question.

5.2.6 Services and Professions

Set on four continents, activities in this category address IT work (Andrade et al. 2021; Beetson et al. 2020), health services (Bennett-Levy et al. 2021; Henson et al. 2022), journalism and citizen science (Bhawra 2022; Tshabangu and Salawu 2022), digital pedagogy (Ribeiro et al. 2019) and online voting (Budd, Gabel, and Goodman 2019). About half of the sponsoring projects are led by Indigenous academics. Technological orchestrations include proprietary applications and mainstream social media platforms. A shared objective of sampled Indigenous participants is to incorporate their ways of being and knowing into work activities.

Two cases, one featuring tech-savvy Indigenous IT professionals and the other, traditional Indigenous journalists, address a tension between digital skills and successful work experience. On the one hand, the stories of three Māori IT professionals in New Zealand highlight technical proficiencies and the freedom to harness Indigenous culture as a source of creative inspiration. On the other hand, the reports from a small journalistic team in Zimbabwe highlight the struggles of "going digital" without retooling and retraining.

5.2.7 Social Media

Indigenous peoples use Facebook, Instagram, and other social platforms as collectives and individuals, with Facebook being singled out by researchers as an especially popular platform (Carlson and Frazer 2021; Dejmanee et al. 2022). Indigenous peoples have demonstrated fluency with the full range of social media affordances (e.g., hashtags, newsfeeds, check-ins, video posting, etc.) to establish voice, challenge dominant narratives, buy and sell, maintain family relationships, and express identity (Hasan, Bao, and Miah 2022). Some practices, such as spoofing one's location to counter the surveillance efforts of settler authorities (S.Z. Zhang et al. 2021), are noteworthy subversive maneuvers that bypass the intentions of system designers (Béguin and Rabardel 2000).

Collective uses of social media include social activism, community development, and cultural reclamation, relying heavily on the Groups functionality of Facebook (Zuckerberg 2017). Notable activist efforts include:

- North American Dakota Access Pipeline (Deem 2019) and Trans Mountain pipeline (Karsgaard and MacDonald 2020) protests,
- #Aboriginallivesmatter (Dejmanee et al. 2022), #IdleNoMore (Richez et al. 2020), #StandingRock (S.Z. Zhang et al. 2021), and Indigenous LGBTQI + hashtag campaigns (Farrell 2021),
- Decolonial photobombing (Miner 2021),
- and Indigenous language revitalization movements (Pavez 2022).

These political efforts align with those of other disempowered non-Western collectives (Chunly 2019; Clarke and Kocak 2018; Lokot 2018; Mosconi et al. 2017; Patrut and Stoica 2019).

Overall, research on Indigenous uses of social media highlights five notable tensions. First, digital divides are evident among Indigenous peoples, with tech-savvy youth and digital professionals achieving greater online influence. Second, several academic authors in this category adopt strong critiques of Euro-Western culture while excluding social media platforms from this critique. Third, some studies find that "hashtag campaigns" have little effect on settler government policy (Richez et al. 2020) and are frequently coopted by a cult of celebrity (Dejmanee et al. 2022; Farrell 2021). Fourth, although subversive practices like location spoofing may confuse settler authorities, such practices also heighten online misinformation concerns (S.Z. Zhang et al. 2021). Finally, and most troubling, Carlson and Kennedy (2021) find that Indigenous people often experience intense online harassment from non-Indigenous people in social media.

5.2.8 Tech 4.0

Tech 4.0 activity systems foreground emerging "smart" technologies championed by transnational programs such as

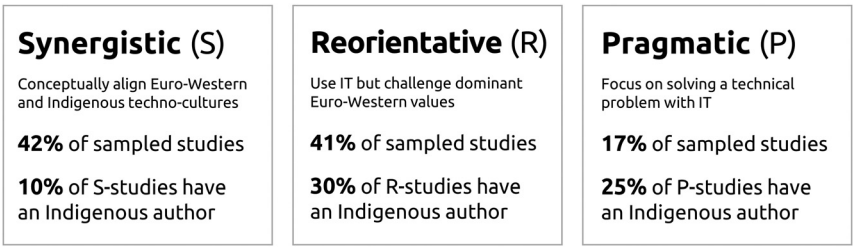

Figure 4: Frame concentrations and Indigenous representation.

Industry 4.0 and Society 5.0 (Blayone and Van Oostveen 2020). Activity system orchestrations in this category feature:

- 3D photogrammetry and computer-aided pattern matching (Gonzalez-Quevedo et al. 2021; Tashi and Ullah 2019),
- AR and VR systems (McMahon et al. 2019; Shedlock and Vos 2021; Park et al. 2022),
- Cybersecurity systems and protocols (Plosker and Srivastava 2021),
- and AI systems (Sohail et al. 2021; Yogarajan et al. 2022).

Academic and technical specialists, two of whom self-identify as Indigenous, take leading roles in this category. There is also a strong emphasis on educating Indigenous peoples and infusing IT practices with Indigenous culture. Some major emerging technologies, like robots, are absent from the sampled studies. However, a non-Indigenous researcher at a Canadian university has proposed a Mi'kmaq AI chatbot (Sohail et al. 2021).

A strong tension in this category is the underrepresentation of Indigenous technologists. The recurring emphasis on gaining the trust of Indigenous peoples raises the question of whose needs and interests are represented when developing cutting-edge "Indigenous" technology solutions. This tension is consistent with the persistent colonial tendencies of mainstream academic practices, which includes "settler-splaining" (Cordes 2021). However, given the strong technology adoption rates among Indigenous youth (Carlson and Frazer 2021) and the efforts of emerging collectives like the Indigenous Protocol and Artificial Intelligence Working Group (2020), Indigenous technologists will increasingly pursue high-tech opportunities on their own terms.

5.3 RQ3. Framing the Cultural Interface

Three ideopolitical framing orientations were identified in the sampled articles and labelled *Synergistic* (*S*), *Reorientative* (*R*), and *Pragmatic* (*P*). All articles tend toward one of these orientations, some more forcefully than others. The overall frame distribution is *S* (n = 29), *R* (n = 28), and *P* (n = 12). Key findings are presented in Figure 4.

5.3.1 Synergistic Frame

The *S* frame combines Indigenous and Euro-Western techno-cultures – a perspective conceptualized as "bi-cultural" (Marques, McIntosh, and Carson 2019), "bothways" (Guthadjaka and van Gelderen 2019), or "two-eyed seeing" (Bhawra 2022). The latter concept entered scientific scholarship in the early 2000s via the work of Mi'kmaq elder Albert Marshall and the integrative science and Aboriginal pedagogy programs at Cape Breton University, Canada (Hatcher et al. 2009; Bartlett, Marshall, and Marshall 2012). This framing orientation promotes Indigenous knowledge while deploying Western technology perspectives such as "affordances" (Karsgaard and MacDonald 2020), and "actor networks" (S.Z. Zhang et al. 2021). Some *S*-framed studies emphasize continuities between online media and Indigenous storytelling (Henson et al. 2022). Others adopt formal cross-cultural protocols, such as the Utility, Self-Sufficiency, Access, and Inter-relationality (USAI) framework (Sanchez-Pimienta, Masuda, and M'Wikwedong Indigenous Friendship Centre 2021) and the Research Data Alliance's CARE principles (Carney et al. 2022). Notably, the *S* frame is optimistic. It portrays Indigenous IT users as capable agents not held captive to colonial histories, biased algorithms, or exploitative socio-political systems.

Six of eight activity categories are represented in this *S*-frame cluster. General technology use and geospatial projects are absent. However, only 10 % of these articles have at least one author who self-identifies as Indigenous. This raises the question as to what degree cultural hybridization belongs to a multi-cultural settler strategy detached from Indigenous self-determination goals.

5.3.2 Reorientative Frame

2The *R* frame draws a sharp line between Euro-Western culture and Indigenous ways of being and knowing. Studies adopting this frame deploy the discursive techniques of critical theory and storytelling to challenge Western economic, scientific, and technological dominance. This includes deploying an activist lexicon featuring constructs such as "entrenched settler ignorance," "erasure," "invisiblization,"

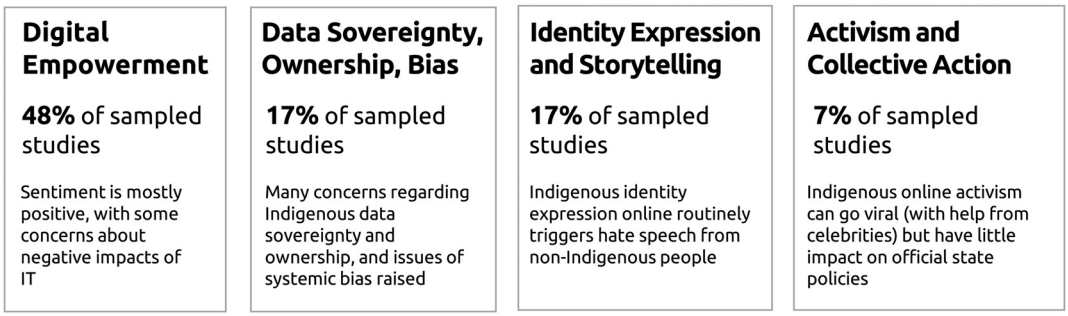

Figure 5: Political issue concentrations and orientations.

"pushing back," "reclaiming," and "unlearning." Some studies adopt an intersectional perspective, merging a general critique of settler culture with more specific targets. For example, Farrell (2021) addresses "heteropatriarchal settler colonialism" that "violently dispossesses" some online Indigenous LGBTIQ + groups and forcibly assimilates them into "European gender, sex and sexual orders" (1). Similarly, Rice et al. (2022) invite consideration that "epistemic ignorance" has gendered dimensions (i.e., that males are often the primary culprits).

The *R* frame appears in articles addressing all eight activity categories, almost 30 % of which have Indigenous authors. Geospatial mapping activities are prominent in this cluster, which exhibit sobering discourse markers such as "putting remembrance back on the map" (Broadhead 2020), and "digital cartographies of gender violence" (Miner 2022).

5.3.3 Pragmatic Frame

The *P* frame focuses on using digital technology to solve challenging technical problems of relevance to Indigenous peoples, avoiding strong theoretical stances on cross-cultural politics. Examples are found in studies addressing (a) Internet access for Indigenous communities in South Asia (Bala and Tan 2021; Hasan, Bao, and Miah 2022; Horn and Gifford 2022), (b) digital modelling techniques for preserving Indigenous cultural heritage in Cuba and Japan (Gonzalez-Quevedo et al. 2021; Tashi and Ullah 2019), and (c) cybersecurity training for Indigenous youth in rural Canada (Plosker and Srivastava 2021).

Six of eight activity categories are represented in this *P-frame* cluster. Social media uses and storytelling, which foreground critical discourses, are not represented. About 25 % of *P*-framed studies have an Indigenous author.

5.3.4 Frames and Research Designs

Regardless of the framing orientation, qualitative methods dominate in the sampled studies, with only a few quantitative (Hasan, Bao, and Miah 2022; Plosker and Srivastava 2021; Yogarajan et al. 2022) or mixed methods (Reihana, Taura, and Harcourt 2019; Carlson and Kennedy 2021) investigations. This is consistent with the perspective that qualitative methods align with tribal epistemologies (Kovach 2021). Two general tendencies are that articles with a strong theoretical component adopt an *S* or *R* frame, while technical reports adopt a *P* frame.

5.4 RQ4. Foregrounded Political Issues

Four political issues are foregrounded in the sampled studies: digital empowerment (n = 33); data ownership, sovereignty, and bias (n = 12); identity expression (n = 12); and activism and collective action (n = 5). A few studies avoid overt political issues (n = 7). Key highlights are presented in Figure 5.

5.4.1 Digital Empowerment

The sampled literature finds that using digital technologies generally enhances Indigenous empowerment at the individual and collective levels. Empowering outcomes include:

- Improved information sharing, connective action, and communication with non-Indigenous power brokers (Bala and Tan 2021; Varea et al. 2020; Dejmanee et al. 2022),
- Increased civic involvement and activism via online platforms (Budd, Gabel, and Goodman 2019; Horn and Gifford 2022; Rivera and Rojas 2021),
- Amplified voices via social media and online cultural resources (Cordes 2021; Nijdam 2023; Gonzalez-Quevedo et al. 2021; Hausknecht et al. 2021; Miner 2022, 2021; Mamontova and Klyachko 2022),
- New forms of cultural expression and hybrid identity development (Gonzalez-Quevedo et al. 2021; Reihana, Taura, and Harcourt 2019),

- Improved digital competencies (Loebach et al. 2019; Park et al. 2022), data gathering and problem-solving (Meisel et al. 2021),
- and technological innovation (Ruckstuhl et al. 2019).

These outcomes are reinforced by Hasan, Bao, and Miah (2022), who find significant positive correlations between IT usage and political and economic freedoms defined by Sen's capabilities framework.

Despite these positive findings, some projects raised concerns, including:

- Limited Indigenous sovereignty over digital infrastructures (Wagner and Fernandez-Ardevol 2020),
- Colonizing pressures of mainstream mapping platforms (Syme 2020),
- A perceived loss of traditional (land-based) knowledge-making practices (Young 2019),
- and the potential misuse of online Indigenous cultural artifacts (Andrade et al. 2021).

5.4.2 Data Sovereignty, Ownership and Bias

Data sovereignty addresses legal jurisdiction over data, often determining how data is stored and processed. Data ownership involves rights and control over data, including the ability to derive commercial benefits. Data bias addresses patterns in the collection, processing, or interpretation that can lead to skewed results in some contexts. These are closely related constructs and are, therefore, treated together. Each construct affects the fairness of emerging data automation systems (Zajko 2021).

The sampled studies address data ownership (n = 6), data sovereignty (n = 4), and data bias (n = 2) as investigative foci, procedural concerns, or discussion items emerging through interaction with Indigenous stakeholders. Data sovereignty and ownership issues arise in producing online platforms featuring Indigenous knowledge (Carney et al. 2022; Ellis, Macdonald, and Almeida 2022; Jennings, Johnson-Jennings, and Little 2020; Montenegro 2019). Specific cases include (a) Māori IT professionals disseminating cultural symbols online (Andrade et al. 2021), (b) researchers establishing citizen science collaborations with Indigenous communities (Bhawra 2022), and (c) academics creating digital artifacts from Indigenous languages and literature (Bow 2019; Langdon 2020) or geographic information (McMahon et al. 2019; McGurk and Caquard 2020). One notable discourse marker in research reporting relates to "claiming" (Andrade et al. 2021) versus "giving" or "ceding" control of data (Bhawra 2022; McGurk and Caquard 2020). The delicate question is who is claiming and ceding, and under what conditions?

Several studies have addressed data *bias*. For example, Yogarajan et al. (2022) highlight dangerous biases in AI healthcare algorithms in New Zealand. They argue that machine-learning procedures must be altered to mitigate biases before an AI model is fully trained. Alvarado, Barriente, and Bigelow (2021) address interpretive biases in the critical edition of an Indigenous literary text using the Text Encoding Initiative (TEI) metadata standard. Notably, uniquely Indigenous alternatives to the TEI have been proposed (Montenegro 2019).

5.4.3 Identity Expression and Storytelling

Identity is a complex psycho-social construct formed by roles, group associations, and individual traits in social contexts (Stets and Serpe 2013). Identities become politicized as they are subjected to social "validation," which can occur online or offline. Indigenous identities, which are linked to Euro-Western colonization, genocide, and consequent programs of (re)conciliation, have a pronounced political dimension in settler states (MacDonald 2019).

The sampled research addresses Indigenous identity politics primarily in the context of online activity. Carlson and Kennedy (2021) find that Indigenous people often become victims of hate speech when they identify in social media. The case studies of Sanchez-Pimienta, Masuda, and M'Wikwedong Indigenous Friendship Centre (2021) discuss emotional storytelling videos addressing Indigenous youth culture and sexual orientation. Similarly, Guzzetti (2022) explores a Navajo woman's writing and illustration practices, emphasizing the "gender fluidity" of Navajo identity constructs. Other studies address (a) the politics of Indigenous artistic expression and audience reception on YouTube (Aguilo 2020), (b) combatting the "erasure" of Indigenous identity in digital stories (Cox 2022), (c) pursuing bi-cultural identities via AR experiences (Marques, McIntosh, and Carson 2019), and (d) advocating for the revitalizing of Indigenous language through social media (Pavez 2022).

5.4.4 Activism and Collective Action

A portion of the sampled research highlights the politics of activism and collective action. Bennett-Levy et al. (2021) describe their efforts to transform a government-funded mental health training program for Indigenous practitioners into a bottom-up and culturally informed learning experience. Broadhead (2020), a settler scholar, introduces two digital (re)mapping initiatives offering cartographic evidence of a past erased from settler histories in Israel and Canada. Henson et al. (2022) investigates how older Indigenous women advocate for their community's health through

social media. Townsend et al. (2020) describe a digital archaeology project conducted by Michigan State University scientists in collaboration with members of the Ani-Kitu Hwagi (Cherokee) community. Finally, Richez et al. (2020) correlate activities of the *#idlenomore* online movement with the documented policy changes of the Canadian government, finding little evidence of a significant positive correlation.

6 Discussion

This study synthesized IT research for Indigenous sociocultural development, revealing a gap in the use of machine intelligence, with only 4 % of studies incorporating AI – a technological divide recognized by some Indigenous scholars (Lewis 2020, 2023). This finding is notable given the potential for LLM models to automate cultural preservation and production tasks. Granted, LLMs did not achieve major press coverage until the 2020s (C. Zhang et al. 2023) and some leading scientists have advised caution when incorporating LLMs into formal research (Morris 2023). At this juncture, however, the "genie is out of the bottle" and ongoing advancements in LLM training, inferencing, and prompt engineering (Ekin 2023; Chen et al. 2023) are sure to expand the role of AI in social-scientific research (Bail 2023). The lack of AI use in the sampled studies signals a disjuncture: while AI is reshaping global ecosystems, many cultural digitization initiatives remain tethered to old computational paradigms.

Nevertheless, the research highlights several notable technical orchestrations. For example, two sophisticated and creative deployments include: (a) a "reverse-engineered" virtual modelling system dedicated to the replication of symmetrically patterned Ainu artifacts (Tashi and Ullah 2019); and (b) the application of 3D photogrammetry for the digitization of Indigenous archaeological sites in the Greater Antilles (Gonzalez-Quevedo et al. 2021). Even within the comparatively "low tech" sphere of digital storytelling, one project deploys cutting-edge GIS technologies aimed at reinterpreting historical narratives of the Rogue River War (1853–1856) (Cordes 2021). Conversely, within the "higher tech" sphere of cultural digitization, there is an account of an "epic failure," leading to the cessation of a transnational digital archive initiative owing to the unanticipated environmental and resource-related hurdles encountered in the Kelabit Highlands of Borneo, Malaysia (Kelly and Taffe 2022).

Moving beyond the characteristics of technology orchestrations, our bifocal perspective yielded several key insights. First, the inverse relationship between technological complexity and Indigenous creative control raises a concern. Low-tech activities (e.g., digital storytelling, social media) that require only user-level skills tend to enhance Indigenous agency, while high-tech projects (e.g., GIS mapping, cultural digitization) often necessitate external expertise, reducing Indigenous control over design and governance. This dynamic echoes colonial dependencies and reinforces digital sovereignty challenges. To counteract this, researchers might prioritize capacity-building initiatives and engage Indigenous technologists rather than framing Indigenous peoples as beneficiaries of external innovation.

Second, tensions sometimes emerge between academic research priorities and Indigenous community needs. Sometimes, technically successful projects aimed at cultural resurgence can fail in practice: archival platforms may remain unused, mapping projects may replicate colonial cartographies, and digitization efforts may conflict with oral protocols. Thus, researcher-led initiatives must contend with epistemological and sociopolitical disjunctions that are sometimes difficult to overcome.

Third, the ideological structuring of Indigenous IT research reveals a split between (a) fostering cultural hybridity (the Synergistic frame) and (b) demanding epistemic and infrastructural reorientation to resist settler-imposed systems (the Reorientative frame). That the research is polarized suggests an unresolved strategic question: Should Indigenous digital futures be built within existing infrastructures, or should they require radical redesign from first principles? Importantly, studies with Indigenous authors are split between discursive resistance and an apolitical, problem-solving perspective (the Pragmatic frame). This pattern implies that non-Indigenous scholars are often leading efforts toward cultural hybridization, while Indigenous scholars are divided between critical and pragmatic responses (Hokowhitu et al. 2021).

Fourth, political themes in the sampled research reflect complex relationships among digital empowerment, data sovereignty, and activism. While nearly half of the studies emphasize digital empowerment, this concept frequently functions aspirationally rather than as a measured outcome. Similarly, data sovereignty is sometimes invoked as a reactive concern rather than a guiding principle. A sobering insight is that while online activism amplifies Indigenous voices, its impact on policy remains uncertain. The ever-present challenge for today's activist is to bridge online and offline strategies while producing tangible results.

Taken together, these insights underscore significant contributions to research. By exposing gaps, complex ecologies, relational tensions, and discursive divides, this study

advances the analysis of human-machine activities and Indigenous cultural advancement through a bifocal, techno-cultural, and ideopolitical lens.

6.1 Limitations

Three limitations of this study must be noted. First, the sampled research addresses a small fraction of the 5,000 Indigenous cultures worldwide (United Nations 2023). Moreover, the framing of Indigenous peoples as agential humans with a strong capacity for learning, crossing cultures, and using digital technologies must be held in tension with deficit narratives that describe Indigenous peoples as among the most disadvantaged and vulnerable people in the world (United Nations 2023). Researching the digital activities of Indigenous peoples is sometimes biased towards those with sufficient access, motivational resources, and digital competencies.

Second, the findings addressing framing orientations in the sampled studies expose clear patterns but smooth some ideological nuances. Some studies fit between the three framing orientations identified. In short, judgment calls were made, and this author did not intend to label the values of participating researchers or their institutions. The framing patterns identified are tied directly to thematic and discursive analyses of published articles.

Finally, formal multi-reviewer literature screening protocols and statistical reliability testing were not part of the selection or analysis repertoires. However, through ongoing discussion, the authors, one with Indigenous heritage and one without, reached a consensus on the rigorous deployment and application of the chosen theories to the systematically selected literature as described. Thus, the overall methodology guiding this critical synthesis is readily defensible and well-aligned with the stated goals.

6.2 Pathways for Future Research

This study showcases an emerging research area featuring creative uses of digital technologies and AI for Indigenous sociocultural development. Perhaps the greatest catalyst for future research comes from eco-perspectives and Indigenous ontologies in which AI entities are considered potential partners and non-human "kin" (Shedlock and Hudson 2022; Lewis 2023). However, anthropocentrism inhibits many AI discourses where "human-level functioning" remains a gold standard. On this point, a leading AI expert has remarked that "in the space of all possible minds, humans are not necessarily all that smart" (Goertzel 2007, 1163).

What kinds of kinship arrangements might Indigenous peoples pursue with advanced AIs? Are the data sets, training repertoires, and "alignment" protocols deployed by "frontier models" adequate for effective human-AI partnering across cultures? Can the open-source AI community surpass the capacities of proprietary AI models and offer more robust cross-cultural inferencing (Hugging Face 2023)? To what degree do Indigenous peoples want culture-specific models, as some contend (Sohail et al. 2021; Lewis 2020)? Does a "bothways" approach (Guthadjaka and van Gelderen 2019) to fine-tuning and prompting address Indigenous needs? What becomes of the Indigenous "self" in a world of hybrid entities and digitally augmented humans (Gladden 2019)?

From another angle, what infrastructural and skill-building initiatives would facilitate greater Indigenous engagement with emerging technologies? Without question, digital skills frameworks (Eshet 2012; Blayone et al. 2018; van Deursen, van Dijk, and Peters 2012) must be expanded to address AI model selection, fine-tuning, prompt engineering, retrieval-augmented generation (RAG), and many other facilitating skills. What attitudes, beliefs, and aspirations enable and thwart successful engagement with AI? Are there good reasons to resist using AI altogether?

Addressing these questions requires abandoning stereotypical and deficit-focused representations of Indigenous peoples. The "we" in debates over AI superintelligence and human-machine alignment implicates the entire human species. Indigenous social scientists must explore emerging techno-social paradigms, engage with experts across cultures, and pursue hopeful futures.

7 Conclusions

This groundbreaking study presented a systematic critical synthesis of 69 studies addressing IT-supported sociocultural development activities by and for Indigenous peoples. Employing two complementary theoretical perspectives, the findings unveiled novel insights into the ecological characteristics of human-machine activity systems and related ideopolitical patterns in academic reporting. Furthermore, it opened new pathways for exploring Indigenous sociocultural resurgence within the context of culturally transformative IT and the emergence of artificial general intelligence.

Appendix

Tabular listing of included studies with key contextual data (n = 69).

#	Year	Authors	Title	Domain[a]	Nation[b]	Curated keywords[c]
1	2020	Aguilo, I.	YouTube kitsch and the racial politics of taste in the andes: The case of delfin quishpe	Latin American culture	Ecuador	Kitsch; YouTube indigenous media; delfin quishpe; indigeneity in Latin America
2	2021	Alvarado, R. C., et al.	Popol wujs: culture, complexity, and the encoding of maya cosmovision	Ethnohistory	United States	Popol wuj; Mayan literature; textual encoding; anthropology; history
3	2021	Andrade, A. D., et al.	Indigenous cultural re-presentation and re-affirmation: The case of Māori IT professionals	Information systems	New Zealand/Aotearoa	Cultural re-affirmation; cultural re-presentation; digital artefacts; indigenous IT professionals; Māori worldviews
4	2021	Bala, P.; Tan, C. E.	Digital inclusion of the orang asli of peninsular Malaysia: remote virtual mechanism for usability of telecentres amongst indigenous peoples	Information systems	Malaysia	Digital inclusion; indigenous peoples; information communication; technologies for development; orang asli
5	2020	Beetson, S. J., et al.	Building a digital entrepreneurial platform through local community activity and digital skills with Ngemba first nation, Australia	International indigenous policy	Australia	Indigenous entrepreneurship; Australia first nations; indigenist standpoint; technology co-design; Ngemba community
6	2021	Bennett-Levy, J., et al.	From digital mental health to digital social and emotional wellbeing: how indigenous community-based participatory research influenced the Australian government's digital mental health agenda	Environment and public health	Australia	Indigenous australians; community partnerships; digital wellbeing; Aboriginal and Torres Strait islander health; indigenous community engagement
7	2022	Bhawra, J.	Decolonizing digital citizen science: applying the bridge framework for climate change preparedness and adaptation	Sociology	Canada	Decolonizing research; citizen science; digital health; data sovereignty; indigenous health; two-eyed seeing
8	2019	Bow, C.	Diverse socio-technical aspects of a digital archive of Aboriginal languages	Archives and Manuscripts	Australia	Indigenous languages; digital archive; language maps; knowledge infrastructure; libraries; Yolngu
9	2020	Briggs, C., et al.	Bridging the geospatial gap: data about space and indigenous knowledge of place	Geography	Australia	Volunteered geographic; information; location-based services; mobile media; GIS systems
10	2020	Broadhead, L. A.	Scales of justice: putting remembrance back on the map in Palestine and Mi'kma'ki	Settler colonialism	Canada	Counter-mapping; palestine; Mi'kma'ki; decolonization; settler colonialism
11	2020	Broadwell, G. A., et al.	Ticha: Collaboration with indigenous communities to build digital resources on Zapotec language and history	Digital Humanities	Mexico/Oaxaca	Digital humanities; cultural digitization; Zapotec language digital resources; indigenous collaboration
12	2019	Budd, B., et al.	Online voting in a first nation in Canada: Implications for participation and governance	Electronic voting	Canada	Online voting; indigenous governance; first nations; self-determination; Canada
13	2020	Burbano, A.	Imagination, indigeneity, and computation: The SIGGRAPH 2018 art Gallery	Arts	Canada	Computer art; indigenous media art; art and science; origins; narrative
14	2021	Carlson, B.; Kennedy, T.	Us mob online: The perils of identifying as indigenous on social media	Genealogical theory	Australia	Indigenous; social media; identity; hate speech; community online
15	2022	Carney, M., et al.	Northwest native plants: A digital space for paleo-ethnobotanical knowledges and biocultural heritage	Geoscience	United States	Ethnobotany; biocultural heritage; digital heritage; online database; indigenous data sovereignty
16	2022	Chazan, M.; Cole, J.	Making memory sovereign/making sovereign memory	Memory	Canada	Decolonization; indigenous knowledge; land as archives; resistance; sovereign memory

(continued)

#	Year	Authors	Title	Domain[a]	Nation[b]	Curated keywords[c]
17	2021	Cordes, A.	Revisiting stories and voices of the Rogue River war (1853–1856): A digital constellatory autoethnographic mode of indigenous archaeology	Critical cultural	United States	Autoethnography and reflexivity; digital archaeology; storytelling voice; settler colonialism
18	2022	Cox, M. M.	Cultural continuance and agency in Cherokee biographical digital storytelling	Communication	United States	Cultural continuance; cultural agency; digital storytelling; Cherokee; settler colonialism
19	2019	Deem, A.	Mediated intersections of environmental and decolonial politics in the No Dakota access pipeline movement	Culture and Society	United States	248.3
20	2022	Dejmanee, T., et al.	#Aboriginallivesmatter: Mapping Black lives Matter discourse in Australia	Media and communications	Australia	Hashtag activism; Black lives Matter; #AboriginalLivesMatter; connective action; indigenous australians
21	2022	Ellis, N., et al.	Taonga in a digital world: Maori adornment and the possibilities of reconnection	Science and technology of New Zealand	New Zealand	Digital heritage; taonga; Māori; tikanga; cultural revitalisation
22	2021	Farrell, A.	Feeling seen: Aboriginal and Torres Strait islander LGBTIQ plus peoples, (in)visibility, and social-media assemblages	Genealogy	Australia	Torres Strait islander; gender sexuality; LGBTIQ plus; social media
23	2021	Gonzalez-Quevedo, E. R. G., et al.	The use of 3D photogrammetry in the analysis, visualization, and dissemination of the indigenous archaeological heritage of the greater Antilles	Archaeology	Cuba	Photogrammetry; virtual archaeology; caribbean archaeological heritage; cuban indigenous heritage; archaeology
24	2019	Guthadjaka, K.; van Gelderen, B.	Designing the warramiri website: A bala-räli bothways duoethnography from the Yolŋu homeland of Gawa	Australian Aboriginal	Australia	Indigenous education; warramiri; Yolŋu; future; anthropology
25	2022	Guzzetti, B. J.	Stories of a healing way: A Navajo woman's media production for cultural representation and identification	Literacy	United States	Digital media literacy; instructional strategies; women and literacy; new literacies
26	2022	Hasan, N., et al.	Exploring the impact of ICT usage among indigenous people and their quality of life: operationalizing Sen's capability approach	Information technology for development	Bangladesh	Capability approach; indigenous people; access; technology; acceptance
27	2021	Hausknecht, S., et al.	Sharing indigenous knowledge through intergenerational digital storytelling: Design of a workshop engaging elders and youth	Educational Gerontology	Canada	Community; education; geriatrics; gerontology
28	2022	Henson, C., et al.	A new path to address health disparities: How older Aboriginal & Torres Strait islander women use social media to enhance community health (protocol)	Digital health	Australia	Digital health; Aboriginal; Torres Strait islander; social media; user-centred design
29	2022	Horn, C.; Gifford, S. M.	ICT uptake and use and social connectedness in rural and remote communities: a Study from Sarawak, Malaysia	Information technology for development	Malaysia	Digital inclusion; Sarawak Malaysia; mobile phone; digital inclusion; development studies
30	2020	Jennings, D., et al.	Utilizing webs to share ancestral and intergenerational teachings: The process of co-building an online digital repository in partnership with indigenous communities	Genealogy	United States	Indigenous health; world wide web; wise practices; digital repository; ancestral teachings
31	2020	Karsgaard, C.; MacDonald, M.	Picturing the pipeline: Mapping settler colonialism on instagram	New media and Society	Canada	Hashtags; indigenous; instagram; issue publics; settler colonialism
32	2022	Kelly, M.; Taffe, S.	When digital doesn't work: Experiences of co-designing an indigenous community museum	Multimodal technologies and interaction	Australia	Co-design; community agency; digital technology; museum; computer science

(continued)

#	Year	Authors	Title	Domain[a]	Nation[b]	Curated keywords[c]
33	2020	Langdon, E. J.	Language documentation and revitalization among the Siona of the Putumayo, Colombia: The potential of digitization for the social life of ethnographic material	Humanities and social sciences	Colombia	Oral literature; digitization patrimony; Siona indians; cultural revitalization
34	2019	Loebach, J., et al.	Keyboard warriors? Visualising technology and well-being with, for and by indigenous youth through digital stories	Visual studies	Canada	Participatory video; challenges; arts & humanities
35	2022	Mamontova, N.; Klyachko, E.	Process Toponymy': A GIS-based community-engaged approach to indigenous dynamic place naming systems and vernacular cartography	Geovisualization	Russia	Indigenous cartography; indigenous toponymy; Siberia; Evenki people; geoontology
36	2019	Marques, B., et al.	Whispering tales: Using augmented reality to enhance cultural landscapes and indigenous values	Indigenous studies	New Zealand/Aotearoa	Culture; narratives; indigenous knowledge; landscape architecture; augmented reality
37	2020	McGurk, T. J.; Caquard, S.	To what extent can online mapping be decolonial? A journey throughout indigenous cartography in Canada	Canadian Geography	Canada/Turtle island	Indigenous cartography; web mapping; decolonized; Canada; nation
38	2019	McMahon, R., et al.	Sweetgrass AR: Exploring augmented reality as a resource for indigenous-settler relations	Communication	Canada	Augmented reality; indigenous media; indigenous-settler relations; production or coproduction; intellectual property
39	2021	Meisel, J. J., et al.	Automated mapping of historical native American land allotments at the Standing Rock Sioux reservation using geographic information systems	Geo-information	United States	Dawes allotment; GIS; map automation; reservation; Standing Rock
40	2022	Miner, J. D.	Informatic tactics: Indigenous activism and digital cartographies of gender-based violence	Communication and Society	United States	Indigenous media; counter-mapping; digital cartography data sovereignty; settler colonialism
41	2021	Miner, J. D.	Ethnographic photobomb: The materiality of decolonial image manipulation	Cultural studies	United States	Digital image processing; ethnographic photography; indigenous media; photobomb; settler digitality
42	2019	Montenegro, M.	Subverting the universality of metadata standards: The TK labels as a tool to promote indigenous data sovereignty	Information science	United States	Traditional knowledge; Dublin Core; metadata standards; indigenous communities; indigenous data sovereignty
43	2023	Nijdam, E.	Recentering indigenous epistemologies through digital games: Sámi perspectives on nature in Rievssat (2018)	Culture	Finland	Sami; Rievssat (2018); 2018 Sami game jam; indigenous worldview; indigenous epistemologies
44	2022	Park, N., et al.	Mixed reality co-design for indigenous culture preservation & continuation	Computer science	New Zealand	Mixed reality; presence co-presence; indigenous
45	2022	Pavez, G. A.	Language ideologies of emerging institutional frameworks of Mapudungun revitalization in contemporary Chile: Nation, Facebook, and the moon of Pandora	Communication	Chile	Language ideologies; language normalization; language revitalization; Mapudungun; sociolinguistics of Chile
46	2021	Pena, R. I., et al.	Wounaan storying as intervention: Storywork in the crafting of a multimodal illustrated story book on people and birds	Genealogy	Panama	Wounaan; conviviality; egalitarianism; movement; temporality
47	2021	Plosker, S.; Srivastava, G.	Cybersecurity education in rural indigenous Canada	Computer science	Canada	Cybersecurity; indigenous; culturally relevant education
48	2019	Reihana, K., et al.	He tohu o te wā–Hangarau pūtaiao/Signs of our times–Fusing technology with environmental sciences	New Zealand Ecology	New Zealand	Environmental education; gamification; kaitiakitanga; kaupapa; Māori; matauranga

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#	Year	Authors	Title	Domain[a]	Nation[b]	Curated keywords[c]
49	2019	Ribeiro, R. G. T., et al.	The pedagogical usage of digital technologies in an indigenous village in Brazil: Reflections and challenges	Interaction design	Brazil	Indigenous education; ICT; digital divide; Guarani indian people; education
50	2022	Rice, C., et al.	Identifying and working through settler ignorance	Critical education	Canada	Epistemic ignorance; affect; de-colonizing education; embodied knowing; digital multimedia storytelling;
51	2020	Richez, E., et al.	Unpacking the political effects of social movements with a strong digital component: The case of #idlenomore in Canada	Social media and Society	Canada	Public policy; political communication; indigenous politics; online mobilization social movements; hashtag activism
52	2021	Rivera, C. A. M.; Rojas, J. A. D.	Technology appropriation and mapuche self-communication: An interpretation of indigenous e-communication in Chile	Sociology and politics	Chile	Mapuche communicators; mapuche e-communication; appropriation; self-communication; intercultural conflict
53	2022	Rosa, F. R.	From community networks to shared networks: The paths of Latin-centric indigenous networks to a pluriversal internet	Information communication	Mexico/Oaxaca	Community networks indigenous design interconnection infrastructure internet governance coloniality
54	2019	Ruckstuhl, K., et al.	Recognising and valuing Māori innovation in the high--tech sector: A capacity approach	Science and technology of New Zealand	New Zealand	Innovation; Māori knowledge; absorptive capacity; entrepreneurship; economics and politics
55	2022	Ruiz, M. V.	Mobile postcards: Zapotec imagined mobility	Mobility and Transportation	Mexico/Oaxaca	Indigenous immigration; digital mobility; settler colonialism; undocumented indigeneity; Zapotec mobility
56	2021	Sanchez-Pimienta, C. E., et al.	From controlling to connecting: M'Wikwedong as a place of urban indigenous health promotion in Canada	Health	Canada	Aboriginal health; urban health; youth; decolonization; resilience
57	2021	Shedlock, K.; Vos, M.	Modelling the indigenous virtual self, using fuzzy logic as a data filtering system	Indigenous studies	New Zealand	Indigenous IT artefact; indigenous digital self; indigenous science; virtual reality; Māori
58	2021	Sohail, M., et al.	AI chatbot an indigenous artifact: For support service to indigenous people emergent research Forum (ERF)	Information systems	Canada	Indigenous; inuit; inukshuk; artificial intelligence; Mi'kmaq
59	2020	Syme, T.	Localizing landscapes: A call for respectful design in indigenous counter mapping	Information communication and Society	Australia	Critical GIS cartography; counter-mapping; localized cultural mapping; indigenist algorithms; decolonizing design
60	2019	Tashi; Ullah, A.	Symmetrical patterns of ainu heritage and their virtual and physical prototyping	Symmetry/Asymmetry in natural sciences	Japan	Symmetrical pattern; ainu culture; point cloud; geometric modelling; 3D printing
61	2020	Townsend, R., et al.	Digital archaeology and the living Cherokee landscape	Historical archaeology	United States	Digital heritage; Cherokee; critical indigenous studies; curation; archaeology
62	2022	Tshabangu, T.; Salawu, A.	Technology innovation and digital journalism practice by indigenous African-language newspapers: The case of Umthunywa in Zimbabwe	African journalism	Zimbabwe	Digital journalism; critical theory of technology; indigenous; African-language newspapers; journalism innovation
63	2021	Vaarzon-Morel, P., et al.	Sharing and storing digital cultural records in central Australian indigenous communities	New media and Society	Australia	Central Australia; digital cultural records; digital inequalities; digital infrastructures; indigenous media
64	2020	Varea, R., et al.	The political affordances of the "coconut wireless" Rotumans on social media in the 2018 Fiji elections	Pacific journalism	Fiji	Fiji; digital diaspora; freedom of expression; Rotuma; social media
65	2019	Vett, M.	Australian indigenous art centres online: A multi-purpose cultural tourism framework	Arts	Australia	Australian indigenous art; indigenous tourists; art centres; cultural tourism; websites

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#	Year	Authors	Title	Domain[a]	Nation[b]	Curated keywords[c]
66	2020	Wagner, S.; Fernandez-Ardevol, M.	Decolonizing mobile media: Mobile internet appropriation in a Guarani community	Mobile media and communication	Argentina	Communicative ecology; community communication; cultural revitalization; decolonization indigenous media; mobile
67	2022	Yogarajan, V., et al.	Data and model bias in artificial intelligence for healthcare applications in New Zealand	Computer science	New Zealand	Artificial intelligence; bias healthcare; New Zealand; Māori
68	2019	Young, J. C.	Rural digital geographies and new landscapes of social resilience	Rural studies	Canada	Digital geographies; rural-urban divides; community resilience; knowledge politics; climate-change
69	2021	Zhang, S. Z., et al.	Stand with #StandingRock: Envisioning an epistemological shift in understanding geospatial big data in the "post-truth" era	Geography	United States	Big data; epistemological shift; indigenous people; location spoofing; post-truth

[a]Domain is inferred from the publication's statement of scope. [b]Country names reflect the study context, not the authors' country of residence. Indigenous country names are indicated when provided by the authors. [c]Authorial keywords were curated by this author and reduced to a maximum of five key items relating to place, peoples, technologies, purposes, and critical perspectives.

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