

**STEM Educational Outreach and Indigenous Culture: (Re)Centering for Design  
Scholarship**

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### **Abstract**

Integrating Indigenous culture into STEM education is a critical process in building pathways to justice and diversifying design. This process serves to (re)center our conceptions of STEM education by challenging strictly Western notions of STEM, representing an opportunity for learning not just in curricular design, but in technological design as well. Postcolonial computing scholars have critically examined design processes, highlighting the dominance of Western knowledge undergirding cross-cultural design. However, such efforts have yet to fully leverage insights from national curricular (re)centering initiatives. We take up this opportunity through a qualitative case study of an educational outreach organization in British Columbia, Canada, a subsidiary of a nation-wide effort in curricular integration of Indigenous and Western STEM material. Applying postcolonial computing thought, we offer enrichments to theory by providing an empirical basis for a) integrating resiliency, b) politicization in design, and c) arguments for (re)centering epistemological authority in computing. These contributions both enrich theory and enhance the practice of cross-cultural design by encouraging and exploring an Indigenous (re)centering of our understanding of both curricular and technological design.

## **STEM Educational Outreach and Indigenous Culture: (Re)Centering for Design Scholarship**

National efforts reconceptualizing the relationship between educational systems and Indigenous peoples through integrating Indigenous culture into education are under way in many countries globally (Canavera et al., 2020; Genger, 2020; Rigney, 2017; Williamson & Dalal, 2007), including Canada. Canada's curricular efforts build upon its reconciliation process, which exposed the atrocities committed against Canada's Indigenous peoples through the residential school system (The Truth and Reconciliation Commission of Canada, 2015a). The commission produced a 'Calls-to-Action' (The Truth and Reconciliation Commission of Canada, 2015b), including a recommendation for the integration of "culturally appropriate" educational content through, what aims to be, a transformative process for traditionally Western education.

This different view of education constitutes a form of *(re)centering*, shifting what Western educators have long taken for granted as the core knowledge base of an educational curriculum. We employ an adapted form of Souto-Manning & Rabadi-Raol's (2018) definition of *(re)centering*, containing both centering and recentering that reorients a "people of color's ontologies and epistemologies foundationally to interrupt" narrow, Western definitions of knowledge and education. Through integration of Indigenous culture into education, science, technology, engineering, and mathematics (STEM) outreach programs are undertaking this *(re)centering* practice, in many cases hosted within Canada's larger Western institutions of learning and education. In these contexts, close interaction is required between educators, administrators, community representatives, and holders of cultural knowledge.

In the parallel discipline of technological design, postcolonial computing scholars have explored similar processes, deconstructing the Western-centric notion of the 'center versus

periphery,’ and reconceptualizing technologies by identifying and challenging the social and cultural assumptions ingrained in hegemonic designs. These efforts have defined a (re)centering task within design that involves indigenous epistemological outlooks (Sultana & Ahmed, 2019; van der Velden, 2013; S. Wyche et al., 2015), interrupting narrowly hegemonic Western definitions of technological design.

Curricular and technological design projects share the goal of integrating multiple conceptualizations of knowledge. Yet, they both reignite a host of colonial and postcolonial issues, including questions of epistemological negotiation, power circulation and asymmetries, and technical versus cultural expertise. These themes, derived from a shared historical backdrop of colonialism, are common to cultural integration in both curricula and technological design efforts, and the challenges of designing cross-colonial, cross-cultural education and technology often go hand-in-hand, especially given the Western designer – Indigenous community template. Education, by its very nature, is forward-looking and aspirational, yet has an essential tradition in contextualizing understanding within broader forces like historical oppression and colonialism. Making this connection expands our understanding of what underlies cross-colonial technological design, and can lead to more deeply understood (re)centered design frameworks.

To this end, we analyze a case study of integrating STEM curricula within a nonformal educational outreach program in Vancouver, British Columbia, through the lens of postcolonial computing theory. We framed the empirical analysis using three of postcolonial computing’s tenets of generative culture, critiques of the involvement of powerful actors, and circulation of power in the integration process. Then, we enrich postcolonial computing theory through three scholarly contributions: 1) we provide an empirical basis for greater integration of resiliency theory, 2) we provide further justification for politicization of design, and 3) we extend and

empirically evaluate arguments for the (re)centering of computing's epistemological authority, drawing on the fourth tenets of postcolonial computing which centers on the socio-cultural structures around knowledge production. These contributions both enrich theory and enhance the practice of cross-cultural design by encouraging deeper understanding of the contexts of coloniality.

## **Background and Related Work**

### **Cultural Integration in Nonformal STEM Education**

Indigenous knowledge integration into Western curricula serves a variety of goals, and is undertaken in diverse educational settings. So-called 'indigenization' initiatives combine cultural integration goals with Indigenous voice and leadership. Examples include land-based pedagogy (Haig-Brown & Dannenmann, 2002; Rollo, 2018; Simpson, 2014; Wildcat, McDonald, Irlbacher-Fox, & Coulthard, 2014), and integrating a traditional Ojibwe game called Snow Snakes, referred to as 'Gooneginebig' in Ojibwe, with STEM educational material within a broader framework of Adventure Learning (B. G. Miller et al., 2012). Because indigenization sets a high standard for integration practices, many cases still do not meet the threshold of Indigenous leadership required to be considered indigenization. Nonetheless, integration efforts view indigenization as aspirational, with allied objectives and goals, as well as offering lessons for integration efforts.

The benefits of integration are at least two-fold: 1) as enhancing learning outcomes for Indigenous (and non-Indigenous) learners, and 2) as leading to a more just power relationship between Western and Indigenous communities, expressed through the creation of space for Indigenous epistemologies in Western educational institutions. The enhancement of learning outcomes through shifting the epistemological center traces from the observation that Indigenous

students have historically struggled within Western educational models, problematizing the implicit assumption of the efficacy of these models (DeCoito & Gitari, 2014; Mckinley, 2013; Wildcat et al., 2014). These efforts have largely manifested in integrating Indigenous pedagogical models and content, such as the aforementioned Snow Snakes for teaching STEM (B. G. Miller et al., 2012), practices which have been known to benefit Indigenous and non-Indigenous students alike (Riggs, 2004).

Viewed more broadly, cultural integration also serves as a response to injustices by creating a space within the academy for Indigenous epistemological perspectives and cultural practices. In turn, this should result in power sharing by “reorient[ing] knowledge production based on balanced power relations” between Western and Indigenous peoples (Gaudry & Lorenz, 2018). In this way, curricular integration programs are just as much about their grounding in a broader campaign for Indigenous rights, self-governance, and resisting cultural hegemony as they are in educational outcomes (Armstrong, 2013; Richardson & Blanchet-Cohen, 2000).

Integration efforts are not above criticism. Efforts have been critiqued for hiding the historical realities of colonization and injustice (Darlaston-Jones et al., 2014), and turning the term ‘decolonization’ into a buzzword with little meaning that can hide white-settler culpability in the current state of Indigenous oppression (Tuck & Yang, 2011). Similar concerns were expressed in a study of indigenization programs: “[indigenization] should not manifest as universities using Indigenous knowledges, motifs, languages, etc., as ‘window dressing’, but should result in substantive change across the entire academy.” (Gaudry & Lorenz, 2018). Hauser & Howlett’s comparative analysis of two Canadian university’s efforts justifies these

fears, citing a lack of true institutional commitment to supporting an indigenized program (Hauser et al., 2009).

These findings raise the question – might efforts outside formal educational institutions fare better? Indeed, there is evidence to suggest this possibility. Alternatives to formal education include informal and non-formal forms. Informal education occurs outside any organized educational structure or enterprise, focusing on “lifelong learning” that engages lived experiences from one’s environment (Coombs et al., 1973). In contrast to both formal and informal education, non-formal education takes place outside of traditional schooling but within an “intentional and systemic educational enterprise” (Kleis, Lang, Mietus, & Tiapula, 1973 as cited by Etling, 1993). Non-formal educational practices that adapt “to the unique needs of the students” (Kleis, Lang, Mietus, & Tiapula, 1973 as cited by Etling, 1993) have been reported to be more inclusive of Indigenous outlooks (Sumida Huaman & Valdiviezo, 2014), and supportive of distinct epistemological considerations and Indigenous agency (DeCoito & Gitari, 2014).

While perhaps a better fit in theory, non-formal education is not without its challenges as a mechanism for integration. Bonny (2018) highlights the potential hurdles in an analysis of an Indigenous outreach program. The author describes the day-to-day experiences of STEM educational outreach student assistants working with Indigenous communities in Canada. The analysis identifies the substantial operational challenges of providing even basic educational services in the unique physical, geographical, and cultural contexts of Indigenous communities. Although Bonny does not report on Indigenous cultural integration practices, the analysis highlights the real logistical and political challenges non-formal education faces generally.

The heterogeneous nature of STEM likewise stands to surface distinct challenges between fields. Simple acceptance of the umbrella of STEM tends to mask the uneven

intellectual territory cultural integration faces across disciplines. Substantial contributions and efforts by educators and scholars, particularly those of Indigenous origins, have highlighted the foundations of computing in traditional knowledge systems. However, there is still a lack of empirical analyses that place these practices within broader STEM umbrellas. Thus, the heterogeneous nature of STEM can become masked, and in turn hide the uneven intellectual territory cultural integration faces across disciplines.

### **Computing Foundations in Indigenous Knowledge**

The foundations of computing knowledge are not unique to Western knowledge systems, but rather have been evident in Indigenous knowledge practices long before the advent of the modern computer. The existence of computing fundamentals have been highlighted in the computational complexity exhibited in biodiversity maximizing practices by Native American Communities (Eglash, 2002), production rule systems in Ojibwe scrolls (Eglash, 2002), application of information theory in traditional communications practices (Eglash, 2002), geometric algorithm design exhibited in traditional African circular architectures (Eglash et al., 2011), and traditional basket weaving practices as exhibiting computational and mathematical concepts at the foundation of coding (Fryers, 2019). Even more advanced computational systems like complex adaptive systems have been shown in traditional ecological practices, such as in the networks of Balinese water temples (Lansing & Kremer, 1993). First Nations architect Douglas Cardinal was not only the first architect to incorporate computing into his work (Eglash et al., 2020), but also foundationalized his groundbreaking architectural work in traditional and ancestral knowledge from his Anishinaabe roots (Cardinal, 1998). Mathematician Mary Golda Ross of the Cherokee Nation was a fundamental pioneer of the NASA space program (Y. Smith, 2019), setting the foundation for generations of NASA computing to follow.



A greater awareness of Indigenous knowledge systems as providing theoretical and mathematical foundations for computing has paved the way for developments in education that highlight this epistemological trajectory, most notably ethnocomputing. Ethnocomputing examines and confronts the sensitivity required in transferring computing between contexts, paying particular attention to elements of culture and society (Duveskog et al., 2003; Tedre et al., 2006). It embraces the notion that “technological systems are socially produced, and social production is culturally informed”, calling for a reframing of interactions between ICTs and ‘other’ knowledges, as a negotiation of cultural and technical expertise [21]. Ethnocomputing approaches, therefore, constitute a space of epistemological encounter, where ‘other’, local epistemological outlooks, interact through the medium of technology, generating both educational tools and novel pedagogical practices. These are aligned in theory with notions of (re)centering, as well as in practice with cultural integration.

The development of educational tools addresses the need for connections between technical concepts and indigenous knowledge. In particular, ethnocomputing scholars and practitioners search for parallels to concepts of “algorithms, data storage, or other informational structures” in Indigenous cultural practices, such as “iterative patterns in weaving”, or “binary codes in divination” (Lachney, 2016). In many cases, this produces co-developed and co-designed culturally salient technological artifacts to assist in education. While explored globally, some examples from North America include a pair of foundational studies by Eglash, Bennett, O’Donnell, Jennings, & Cintorino (2006) and Eglash (2007) conducted with Native American communities exploring beading practices to teach mathematics concepts (ethnomathematics) and digital technologies simulating traditional root baskets; Searle & Kafai’s (2015) and Kafai, Searle, Martinez, & Brayboy’s (2014) work with Native American students in Arizona engaging

Indigenous traditions of crafting to teach basic concepts of computing through electronic textiles (e-textiles); and Searle et al.'s work with Native American students in the Southwest connecting augmented reality and interactive storytelling (ARIS) education with students' own cultural knowledge, guiding students through the process of telling stories of import to their local community through these technologies (Searle et al., 2017).

Tools are not the only end goal of ethnocomputing efforts, as some scholars choose to focus on computing pedagogy itself. For instance, in South Africa, Dalvit, Murray, & Terzoli (2008) integrated Indigenous knowledge through culturally relevant metaphors and examples to teach an existing computer science course. In Tanzania, Duveskog et al. (2003) leveraged the ethnocomputing concept of "culturally relevant entry points" to motivate students to learn basic programming concepts in Java to discuss normally culturally taboo topics, in this case sexual health (HIV/AIDS). Their approach capitalized on the perceived non-human nature of the computer as an ideal, non-judgmental space for such topics to be encountered.

These approaches show integrating ICT education and Indigenous cultures is indeed possible, and the findings are generating attention in the computing education discipline. However, as the focus is often narrowly tailored to defining connections between specific cultural practices and lessons, a range of important contextual factors are necessarily underemphasized. First, ICT education is integrated into a variety of settings (formal or non-formal; within broader STEM programs), and a more contextualized view of this embeddedness can further illuminate novel processes of integration, potentially varying across these contexts. Second, although notions of power are foundational to integration and its orientation towards justice, more stands to be said about what the actual findings of integrating ICT education suggest about postcolonial relationships. Notions of power are certainly touched upon in the

ethnocomputing literature, for instance Searle & Kafai (2015) discuss the history of Western dominance of technological narratives and how this dominance emanates from the history and structures that oppress peoples and their forms of knowledge. But ethnocomputing scholarship does not necessarily explicitly represent these processes within broader postcolonial frames. Also, the placement of ethnocomputing between the fields of computer science and education typically leads scholars to pursue goals of extending indigenous curricula across educational levels (K-12 into higher education) or integrating new technologies (for example Searle's (2016) future directions), foreclosing the likelihood of a deeper treatment of power. As a solution, this study contributes to ethnocomputing scholarship by connecting a formalization of the role of justice within Indigenous cultural integration to broader colonial structures.

### **Postcolonial Computing as a Broadening Framework**

Integration of Indigenous cultural material into curricula crucially confronts the power structures formed and fixed through colonization that continue to this day. Insights for this task are gleaned from the broad perspective of post-colonial theory derived from Edward Said's (1978) linguistic constructions of the 'other,' particularly through discourse and the centers of power defining its nature and content. Understanding definitions of and the role of 'the other' in culturally integrated computing curricula are key to (re)centering epistemologies. Furthermore, as integration necessitates discourse, identifying the power centers defining its nature and content are critical elements of the negotiations surrounding these practices.

As an extension, postcolonial computing theory emphasizes the power-laden and culturally located aspects of design (Irani et al., 2010). A constituent element of this process is a "shift in perspective," necessary when technical knowledge transfers across borders (Irani et al., 2010). Postcolonial computing scholarship often finds a home in research conducted in the

‘global south’, including exploring alternatives of technological design (van der Velden, 2013; S. Wyche et al., 2015), integration of ICTs within local cultural fabrics and day-to-day life (Chandra et al., 2017; S. P. Wyche et al., 2015), and the impact technological designs have on local built environments (Mim & Ahmed, 2020). These perspectives are largely juxtaposed against technological design and use in the ‘global north,’ making implicit assumptions about how technologies integrate with global south communities (Ahmed et al., 2015; Dourish & Mainwaring, 2012) and the manifestation of those assumptions in technological design spaces (Merritt & Bardzell, 2011; van der Velden, 2013).

Irani, Vertesi, Dourish, Philip, & Grinter (2010) cite several examples of relevance to computing, illustrating four core tenets undergirding a postcolonial computing perspective. First, they depict the generative nature of culture through perceiving the challenges with conceptualizing cultural differences between technological development ‘here’ versus ‘there,’ arguing for a more dynamic vision of culture that incorporates the daily enactment of it in people’s lives (pp. 3-4). Second, they highlight alignment of corporate actor’s with humanitarian development interest’s in the broader international development industry, applying established critiques to this work, including a) the humanitarian and development regimes’ avoidance of challenging large-scale actors’ (like governments) roles in oppression; b) power asymmetries stemming from international development’s alignment with powerful corporate and governmental actors; c) the parallel between modern day developed-to-developing country technology flows and historical colonial relations; and d) the disempowerment resulting from positioning developing country ‘co-designers’ as consumers within a capitalist system. Third, they point out that the power differentials that stem from the uneven economic relationships and their powerful impacts on the legitimacy of design, as power centers can use legal and political

means such as intellectual property to control design in the developing world. Fourth, they illustrate that knowledge itself hinges upon a complex set of factors, including infrastructure and the socio-cultural structures, and that approaches to management of knowledge cannot be viewed uncritically as universal.

These four tenets prescribe a sensitivity to particular conditions surrounding and endemic to technologically-centric development projects that seek a co-design approach between global north and global south actors. By applying this sensitivity to analysis, we believe that postcolonial computing can serve as a useful analytical framework through its capacity to identify potentially problematic features and promoting a critical reading of development initiatives.

Indeed, postcolonial computing scholars have explored contributions from Indigenous communities in the design of ICTs in service to development projects. The bulk of these projects focus on including Indigenous people as user populations in the design of technologies. Maja van der Velden's (2013) examination of the absence of an 'Indigenous knowledge' page on Wikipedia identified alternative structures for knowledge archives that yield distinctly different relations between sources of knowledge, arguing for a 'decentered' structure that promotes epistemological plurality. Sultana & Ahmed (2019) identified similar themes with witchcraft and Indigenous knowledge, calling for a further critical examination of the center's view of design legitimacy.

### **(Re)Centering Educational and Technological Design Spaces**

Fundamentally, developing integrated educational curricula is an attempt to co-build something that reflects the epistemological foundations of both Western and Indigenous communities, and is therefore akin to a cross-cultural design task. The shared issues of design for

technologies and curricula at the colonial border stem largely from key similarities in their foundations, yielding similar orientations and methods. Both disciplines encounter the challenges of representation: Indigenous peoples in Canada remain statistically underrepresented in tech fields (Gilpin, 2019; Vu et al., 2019), while Indigenous students in Canada lag behind non-Indigenous peers in student educational attainment (“Profile of Indigenous Canada: Trends and Data Needs,” 2020). Both disciplines also critically engage what it means to be inclusive in design: Indigenous education asks itself what meaningful inclusion in educational design looks like (Mckinley, 2013; Pidgeon, 2016; Wildcat et al., 2014), while technological design critiques its own use of participatory design (a common method of community engagement in HCI and ICTD research (Irani et al., 2010)), including its capacity to be reproduced across different contexts (as is the case with working with multiple communities) (Muller & Druin, 2012), or challenging its capacity to be empowering at all (Peters et al., 2018).

Crucial too is the increasing awareness of the need to decolonize participatory design practices (Charlotte Smith et al., 2020; Peters et al., 2018; R. C. Smith et al., 2020). Decolonizing education has long been a concern of Indigenous education (Hudson, 2016; Padilla, 2019), representing a convergence of mindsets evinced by the nature of design work at the colonial border. Further, cultural integration’s goal of redistributing epistemological power (Gaudry & Lorenz, 2018) coheres with postcolonial computing’s (and related fields) challenging of a hegemonic notion of knowledge (Dourish & Mainwaring, 2012; Sultana & Ahmed, 2019; van der Velden, 2013).

The upshot of these strong parallels is that each of these fields can contribute insight to the other. Drawing on postcolonial computing theory’s applicability as an analytical framework composed of the four aforementioned tenets, we propose to explore the following question: *what*

*can cultural integration of non-formal ICT and STEM education and postcolonial computing perspectives learn from one another?* As will be explained in further detail below, the context of our study - a Western institution's non-formal educational services to Indigenous communities in the global north - foregrounds both the colonizer and colonized, including technological designers working in cross-cultural contexts. As such, our case study emphasizes the 'colonial' in postcolonial, providing an opportunity for greater focus on this key construct, as compared with studies where marginalization and colonization are conflated. Therefore, we also explore the question of *what the insights gleaned from cultural integration of ICT curricula and postcolonial computing suggest about the impact of the colonizer-colonized relationship on technological design?*

## **Methodology**

### **Study Design**

We used an evaluative, qualitative case study method informed by Merriam (1988, 1998), relying on data collection from semi-structured interviews, related observations, and document analysis, focusing on an educational outreach organization as our 'bounded phenomenon'. Our data analysis follows the qualitative coding and thematic analysis process specified by Braun and Clarke (2006) and Braun et al. (2018).

This research passed three levels of ethics approval, including at the researcher's home institution, the organization's institution of UBC, and the K'omoks First Nation community. In gaining these approvals, the lead author received specialized training from UBC on conducting research with Canada's Indigenous peoples.

### *Organizations and Communities*

The bounded phenomenon of the case study was the Geering Up Engineering Outreach program managed by the University of British Columbia (UBC) in Vancouver, British Columbia, Canada. The field portion of the case study was conducted over 2 months during the summer of 2019. We also worked with nearby K'omoks First Nation in Courtenay, British Columbia, Canada.

The Geering Up organization provides educational outreach services to both students and teachers in the Vancouver area and external First Nations communities throughout the province of British Columbia, boasting a wide geographic range of coverage. They are a member of Actua, a nation-wide educational outreach organization with network affiliates hosted at numerous institutions of higher-learning throughout Canada (41 in total<sup>1</sup>, with 6 in British Columbia). In particular, Geering Up (and many other network members of Actua) have made a commitment to working closely with Indigenous communities to develop culturally-appropriate curricula with those communities. Geering Up is largely staffed by undergraduate or freshly graduated students, with the exception of higher level administration being full-time positions. Their disciplines are largely confined to the sciences and engineering, with some studying Education as well, and their age range is in the early to mid-20s range. Crucially, Geering Up also served as the host of the research, allowing the lead author to leverage their long term presence and experience with communities to provide needed background to enable and contextualize the data, such as participant responses.

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<sup>1</sup> <https://www.actua.ca/en/programs/all-programs/>



K'omoks First Nation is a small community on Vancouver Island (approximately 200 registered members (Government of Canada, 2016)), and one of the several First Nations communities that Geering Up is working closely with on culturally appropriate curricula.

### **Data Collection**

We used three primary data sources in this case study: 1) semi-structured interviews, 2) observations, and 3) documents. Although we treated interviews as the primary data source, contributions of observation and documents enable a “triangulation of sources” for the phenomenon of cultural integration within this case study (Patton, 1999), a form of triangulation common within case study (Stake, 1995).

### ***Semi-Structured Interviews***

The lead author interviewed 9 members of Geering Up's staff (13 total interviews), using a theoretical sampling procedure in accordance with a postcolonial perspective. The lead author also interviewed 4 members of K'omoks First Nation (4 total interviews), and 3 related community members who were not necessarily Indigenous themselves, but relevant to the outreach program (3 total interviews). These interviews were conducted either in-person in a setting of the participants choosing (e.g. a coffee shop or conference room), or remotely via teleconference, especially in follow-up interviews.

For these interviews, we used a snowball sampling procedure through the community's education coordinator, which allowed us to validate and receive permission from the community before contacting potential participants. These participants ranged in age from an early 20s student all the way to a community elder.

All interviews were voluntary (no payment), and were approximately 30 minutes to 2 hours in length each, covering topics around conceptualizing STEM educational outreach and

indigenization of lessons. Interviews were recorded when allowed, to allow for transcription and ease of analysis. Additionally, the lead author took interview notes to likewise support analysis and understanding.

### ***Documents***

We focused on two organizational sources for document analysis: 1) Geering Up and 2) Actua, the latter of which whose goals and intentions set the context for their network members, including Geering Up. We included two types of documents from these organizations: a) web pages from each organization's website that either convey the goals of the program or their practices/programs; and b) media releases from each organization's website announcing noteworthy events and milestones. We also included only include those published after January 1<sup>st</sup>, 2016, which is the year that British Columbia announced its provincial focus on increasing ICT educational access at the K-12 grade level (Lehmann, 2016; Shaw, 2016). This resulted in a total of 51 documents analyzed, which ranged in length from around 100 words to around 2500 words.

### ***Observations***

The lead author also spent a large portion of the two month field study embedded with the Geering Up team, both in their office as well as in the field assisting in organizational practices such as teaching and working with communities, to understand as best as possible the operating context of the organization, and make observations associated with the interview results, as well as give service back to the communities involved as an aspect of beneficence through the research process.

## Data Analysis

The lead author transcribed the semi-structured interview recordings into text for the purpose of analysis, resulting in approximately 30 hours of transcribed audio. The lead author assigned a code to participants to anonymize their representation in the data unless they requested to be referred to by name (as was the case with two participants from K'omoks First Nation). The process specified by Braun and Clarke (Braun & Clarke, 2006) and Braun et al. (Braun et al., 2018) proceeds from familiarization to code generation and ultimately theme construction. The transcribed audio and collected documents were first reviewed by the lead author, and then qualitatively coded in a manner informed by a review of the literature and familiarization with the context through the fieldwork. Coding of two different data sources (interviews and documents) enabled the identification of potential breakdowns, contradictions, and opportunities for code corroboration. Then, themes were constructed both inductively as they emerged, and deductively through the postcolonial computing lens (Irani et al., 2010). All analysis was completed using QDA Miner Lite<sup>2</sup>.

The lead author reviewed the observational data collected in the form of field notes following the field portion of the study. However, as a subservient form of data to the other sources, the lead author did not independently code these notes, treating them instead as contextualizing information for interviews and document analysis.

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## **Reflexivity Statement**

The lead author, who conducted the study design, data collection, and analysis is a cis-gender male, person-of-color, raised in a rural area in the United States of America. The lead author does not identify as Indigenous, and therefore considers themselves an outsider to the First Nations communities and aligned with the colonizing authority and Western academy.

## **Findings**

Here we present the primary themes constructed from the coding process. We constructed two overarching themes composed of smaller sub-themes: a) themes around the process of navigating the Indigenous-Western divide in STEM cultural integration; and b) themes concerning the necessary resources that impact and enable cultural integration to occur. The former theme combines qualitative coding of identity-based cultural differences and navigating the broader epistemological distance; the latter theme combines qualitative coding of the social-cultural capital connection and the necessary educational and ICT resources.

### **The Process of Navigating the Indigenous-Western Divide**

In order to orient the following results of the thematic coding, it is important to have a high-level understanding of how Geering Up currently integrates Indigenous cultural material into their curricula alongside its regular programming. Geering Up offers several services, including one- to two- day workshops and week-long camps at the UBC campus, Vancouver area schools, and external communities, many of whom are Indigenous. Geering Up relies on financial support from several sources. While internally generated revenue from more profitable camps set on the UBC campus likewise plays a role, corporations and government funding are a substantial component of Geering Up's resources. This arrangement did not always have positive outcomes, as one senior employee described a situation where the inclusion of the logo of a

particular corporate sponsor on Geering Up T-shirts offended one of their First Nations community partners, temporarily halting the relationship.

External outreach is conducted by an outreach team that plans their logistics internally, including initial contact, planning, and selecting personnel. The process of building a working relationship typically begins with an initial contact from Geering Up, introducing their services. From there, if a community is interested, Geering Up will begin planning an initial offering, most commonly a week-long camp for remote communities.

According to the outreach director, only once trust has been established does Geering Up consider pursuing more culturally imbued engagements, given the substantial investment of time, energy, and personnel this process requires. This commonly involves an individual within the Geering Up team being selected to work closely with the community, and so becomes dedicated to that relationship, and may involve multiple site visits and consultations over the phone or web, culminating in a customized program with lessons infusing Western and Indigenous notions of STEM. Already challenging, it is exacerbated by integration into the day-to-day challenges of regular operations and planning, as even basic coordination with communities can be problematic, particularly in the summer months when Geering Up is most active.

### *Navigating the Cultural Distance between Geering up and Communities*

Geering Up educators described the difficulty with navigating identity-based cultural distance, stemming from the fact that they themselves are not Indigenous or from the communities that they service in the vast majority of cases. This anxiety was particularly felt in conceptualizing the challenges of integrating Indigenous and Western sciences:

[...] when you're sitting there with a blank page, and they say “I want you to connect chemistry, I want you to make a lesson”, and you're like “who does that relate?” [...]

the biggest challenge is not having that background. I don't have experiences to draw from. [...] I don't want to just fabricate these connections that don't exist. I want them to be real and authentic, and I want them to be honest [...].

Staffers consistently feared overstepping their own cultural knowledge limitations and harming the carefully built relationships with communities. There was in fact external pressure placed on them by scholars at the University of British Columbia to stick to “the science part of it” and stay away from Indigenous culture, which further exacerbated existing anxieties about the cultural distance. Without community-driven guidance, cultural-tailoring represented nebulous territory.

Further complicating matters was the fact that, within communities, cultural knowledge and cultural expertise (especially as those who can serve as a guide for cultural integration) can be difficult to assess. Keisha Everson<sup>3</sup>, a K’omoks First Nation teacher, described the level of cultural practices among communities as being variable:

So...one thing that's important to remember is that, not every community, not every child in every community has a strong cultural backing or cultural experience, so it's always really important not to assume that a community is extremely cultural, or extremely not cultural, if that makes any sense. That, some communities have, have had that kind of embrace the colonizer experience, that are very removed from

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<sup>3</sup> Participant name used with permission, and request of participant.

cultural teachings and cultural experiences. Or there's factions within the community that are, and other factions that aren't.

Identifying sources of cultural knowledge to work with was not just a matter of finding the holders of ancestral and community knowledge, but also a political choice. One community member described how determination of elders potentially highlights community divides:

[...] if you were to ask me, show me where your elders are in your community, I'd go “[community elder]” [...] but that's where it ends, in my mind, to me, in my opinion, because she was raised with culture and she's passing on the culture, the cultural knowledge, and she continues to, until the day she dies, right? If you asked another person, in K'omox on the reserve, you'd get a different answer. “oh yeah, there's like a dozen elders here”, right?”

Identity based cultural distances was more than just knowledge however, as participants on both sides reported the symbolic value of representation among the educators. Said one Geering Up staffer:

...we look different, we look different from everyone there, and that's not good. I want the kids to be able to see themselves in us, and I think that's easier if their ancestry is at least a little bit closer.

Charlene Everson<sup>4</sup>, The K'omoks First Nation's education coordinator, likewise spoke to the importance of Indigenous students being able to see reflections of themselves not just in their educators, but in their education more broadly:

[...] and that's the thing with indigenous kids, and that's the whole goal with indigenous education in general, is making indigenous kids see themselves in sciences, see themselves in healthcare, see themselves in these things, and by highlighting their strengths.

Thus, the identity-based cultural distance evident between Geering Up and the Indigenous communities they serve was apparent in the anxieties it caused in Geering Up staff and the necessary involvement of community leaders like elders to guide the process, albeit itself a potentially nebulous process with the possibility of exploiting community divides. This distance was perceived in both the attaining the necessary know-how required to handle matters of culture as well as connecting to students through representation.

### *Navigating Indigenous and Western STEM Perspectives*

The challenges of navigating distance between Geering Up's staff and the communities took place within a broader discourse between Indigenous and Western epistemologies of STEM. Staffers backgrounded the organization's work within a strong awareness of the epistemological violence that is a product and end-goal of colonization. Thus, staffers perceived the practice of cultural integration as pushing back against this history of violence by manifesting

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<sup>4</sup> Participant name used with permission, and request of participant.



the idea that Indigenous sciences have a place in the modern Canadian context, both as a connection to one's own traditions and a practical approach to STEM:

Creating curriculum is about showing the students in these rural, remote communities, or maybe urban communities that are also Indigenous, that what they've learned at home through their parents or elders or whatever, is still relevant to today's society.

Both staffers and community members echoed the sentiment that, at its core, different epistemological views on STEM were compatible despite the challenges present in bringing them together into a tailored curriculum. Said Keisha Everson:

I personally think that Western science and Indigenous ways of being and knowing are not mutually exclusive, that Indigenous sciences has a lot to offer Western science and vice versa. They complement each other, and support each other's hypotheses 99% of the time. Like when we talk about creation stories or historical accounts of experiences, or understandings of the universe that they very often are quite complementary.

Both staffers and community members described the various perceptions of Western and Indigenous sciences overlapping, such as the traditional hunting practices biological sciences. However, staffers still perceived a fine line with regards to the delineation between epistemologies perspectives. Their experiences spoke to a necessary caution that, while still pursuing integrated curricula, due credence must still be given to the fact that Indigenous perspectives are indeed a distinct point of view. Cultural integration therefore necessitated

striking a balance where both Indigenous and Western outlooks could find home in shared lessons, but nonetheless make clear that two different worldviews still exist.

## **Social and Technical Resources and the Impact on Culturally-Tailoring Education**

### ***The Social-Cultural Capital Connection***

Meeting the demands of cultural integration of curriculum was a time and energy intensive process, reliant upon significant effort from actors on both sides of the equation, community and educational institution. Navigating the cultural and epistemological divide is nuanced and complex, requiring substantial commitment of time and energy, particularly on those with expertise.

For one thing, logistical aspects of everyday operations background any and all work with communities. Communicating plans with communities was inconsistent and sometimes intermittent, so scheduling essential reservations like accommodations for staffers could at times stretch until just a few days before a camp is scheduled. Scheduling and planning challenges combined with the required effort to deliver effective camps, culturally tailored or not, limited the capacity for the organization to find the necessary time and personnel to enable to cultural integration.

Even once certain logistical considerations are surmounted, the need for certain members of the community to be involved in cultural integration was reinforced. Said one community member:

“Interviewing people, elders, knowledge keepers, and do some vetting. And bring in an elder or knowledge keeper who can start it up. Preferably the beginning of each group, I would have someone come in and ground the knowledge.”

Geering Up employees also cited the importance of elders and knowledge keepers in terms of cultural capital:

[...] having an elder is super helpful for people like me, or many other members of our team, because we do have some knowledge, but we don't have the specifics. So if there's an elder there who's talking about the specific cultural practice that they have, then it's so much easier for us to build on that because we all have general science and engineering expertise.

Elders and knowledge keepers were integral in bridging the aforementioned cultural distance that is central to the cultural integration process. Geering Up staff's citations of successful integration efforts, such as teaching tensile strength through traditional weaving methods, centered the role of knowledge keepers in enabling this process. This further highlights the aforementioned navigation of the cultural identity and overall epistemological distance between Geering Up's staff and Indigenous communities.

However, involvement of key community members like elders and knowledge keepers proved difficult to implement in small communities, where the availability of elders and knowledge keepers active enough to assist in the process were limited in both number and availability. Said the K'omoks First Nation education coordinator, Charlene Everson:

I know for K'omoks, there's very limited amount of people... [Elder] really is one of the only people with a lot of that cultural knowledge in our town, in our community.

In addition to suggesting the political nature of identifying sources of cultural knowledge, it explicitly highlights the often limited access organizations like Geering Up have to critical insiders to guide the integration process. Principle in this is the role of human capital, and its

connection to cultural capital, a factor that was so significant that Charlene Everson suggested that cultural integration could be best pursued at this early stage with larger communities such as Musqueam First Nation in Vancouver area, a much larger community than K'omoks First Nation. The pool of cultural knowledge sources in larger communities is much deeper, therefore lessening the load that could be placed upon any individual elder or knowledge keeper.

While broader provincial and national interests in educational Indigenization are generating mandates to integrate Indigenous culture into education, educators are not always readily equipped to undertake this process. In a particularly telling tale, Keisha Everson recounts an example of when mandates do not match necessary training and resources for educators:

That's the thing with the mandatory Indigenous information for teachers in schools right now [...] it's mandatory, but who's going to teach this information? [...] you end up with teachers feeling out of their depth, and maybe not having the resources, maybe not reaching out to get resources, and then you end up with a half-assed hour lesson on Indigenous science, or Indigenous calculus [...] I think it was last year, [friend] said that her younger sister who is in elementary school or something like that, had that mandatory Indigenous teaching. And her teacher ended up teaching them to stack garbage as totem-poles.

Not meeting the need for cultural guidance and support from communities can therefore lead to particularly harmful episodes. Attaining this guidance however also puts a substantial strain on not just the educational practitioners like Geering Up's staff, but also the communities themselves and their available social-cultural capital.

### ***Educational and ICT Resources***

In working closely with communities interested in offering more ICT focused education, the outreach coordinator described the outset of such discussions centering around ICT resource availability in the community:

The only limitation is what they have available. Because most schools will have laptops, but not all of them do, or not functioning. There's a big movement in some schools to get iPads instead of laptops, and they don't function the same way as our activities, so that's the only limitation, and that's a question we ask them, is “what do you already have” so we know what we can take.

Among the STEM offerings, computing education stood out as one of the most resource intensive, generally requiring more advanced (and expensive) equipment such as laptops and robotics to teach the basic concepts of programming, as well as programming educational environments like Scratch<sup>5</sup>. Geering Up maintained several laptops for teaching, sets of “Ozobots”: small robots about the size of a golf ball, and Adafruit chip boards that are used to teach basic computing concepts to students. In the short intervening time period between the end of the field study in August 2019 and this writing, Geering Up has expanded their library of robotics teaching tools further.

However, outreach struggled to use these tools when communities were geographically distant from UBC due to the challenges of transporting these bulky items. In fact, even outreach activities in the immediate Vancouver vicinity (i.e. the Vancouver School Board system) were

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<sup>5</sup> <https://scratch.mit.edu/>

limited due to the difficulty of safely transporting hardware across even relatively short distances. The cost of computing resources like Ozobots, whose price can be over a thousand Canadian dollars for a single set of 14, made safe transport prudent, and in turn a conservative approach to their use in remote communities.

Furthermore, while communities quite commonly had computing resources on site, it was not uncommon for community-based computing resources to be inadequately prepared for the computing activities Geering Up would run. Getting necessary system updates and software packages required either the commitment and know-how of educators in the community, or last minute system preparation as soon as staff from Geering Up arrived in communities. Each case presented significant strain on energy and resources.

To meet the ends of providing computing lessons despite the resource intensive nature of computing, Geering Up leveraged several “unplugged” activities, such as teaching binary code through bracelets. Although originally built as a way of circumnavigate the challenge with using computing resources in computing education, unplugged activities had managed to develop an appeal beyond merely a response to resource constraint. Instead they had become valued for connecting to how “kids like doing things with their hands” as well as being a more accessible form of computing education.

Thus, the customization of ICT lessons was driven less by what cultural connections and aspirations that communities had with regards to digital technologies, but primarily by what resources were available, and in a usable state. When a senior staffer who had worked with communities on increasing computing education was asked about examples of community-driven customization of the computing education, she responded by pointing to resource availability as the primary factor:

PI: Have you ever been asked to customize your coding education, or your digital technology education by an Indigenous community?

GU3: [...] this wasn't something we were specifically asked, but we would be like “these are the things we need, do you have them?” and they're like “no” and then you'd have to change it somehow, right? Like, we had to a lot of things that were unplugged, or things that didn't need a lot of Wi-Fi connections...

## Discussion

### **A Postcolonial Lens on (Re) Centering the Knowledge Enterprise**

In the following section, we apply the postcolonial computing lens to discuss the cultural integration process. We first discuss how the generative view of culture can frame the challenges of cultural integration, arguing for a focus on integration as a process. Then we connect this process to broader issues in corporate alignments in the humanitarian and aid industry. We close this section with an exploration of power's circulation in cross-cultural educational design spaces, and what it suggests about the value of building integrated curricula and (re)centering STEM outreach between Western and Indigenous epistemologies.

#### ***The Generative View of Culture in Cultural Integration***

The anxieties of navigating the cultural distance highlights a pragmatic challenge of integration: it requires substantial commitment and relationship to overcome cultural distance and co-build curricula. This is a non-trivial task at distance, especially when the nature of Indigenous knowledge is tacit and lived (Kaniki & Kutu Mphahlele, 2002). Postcolonial computing scholars argument for taking a ‘generative’ view of culture identifies it as a phenomenon that is dynamically enacted through social existence (Irani et al., 2010). Culture is a

‘moving target’, a living breathing entity, produced and given value in-situ, and includes not just historical cultural practices, but also responds dynamically to social encounters today.

This dynamic, lived nature is also resistant to codifiability (Kaniki & Kutu Mphahlele, 2002), which problematizes practices that assist Western cultural outsiders in handling non-lived cultural material, for instance the writing down and recording of culturally integrated curricula. That is to say, codifying knowledge as a part of developing lessons and curricula can lose the particular local, ecological foundations of Indigenous knowledge (Battiste, 2005; Cajete, 2005; Kirmayer et al., 2011; Pierotti, 2011). The result is that integration attempts struggle at the epistemological level when undertaken by Western institutions, with ultimate outputs (curricula) being difficult to conceptualize within broader organizational practices like transcription and storage, exacerbated by anxieties about representation in personnel. While this calls into question these outputs, we believe this motivates a particular view of integration as a process, undertaken for the value it presents in and of itself. Examining the how this process occurs can illuminate outcomes as the process itself, and accompanying themes of power asymmetry and epistemological negotiations. Thus, a generative view of culture highlights that to find integration’s value, we should look at its process.

### ***Broader Issues in Corporate Alignment***

The fact that a substantial portion of Geering Up’s financial support comes from private corporations opens the organization up to criticisms of corporate alignment, which has been identified as a broader humanitarian and development aid issue (Haan, 2009; Irani et al., 2010; M. M. Miller, 2014). Although often it is difficult to detect empirically whether these alignments have had a direct negative impact on practices (the previously described situation with corporate sponsorship on T-shirts notwithstanding), as a widely known critique of humanitarian programs



it is worth noting as a point of caution. This is pronounced for outreach to Indigenous communities, as many of these educational camps are free to the communities, sometimes through direct corporate support. Construed negatively, this artificially conflates educational interests with corporate interests, and the educational organization is caught in-between, trying to empower communities while leveraging the financial support and national visibility that allegiance with powerful actors enables. The consequence of conflation is that the empowerment of communities becomes inseparable from larger power structures, and risks papering over the role that some larger actors have played in disempowerment in the past.

In this way, Western epistemological centering in education interacts with these programs' centering in a broader, Western-capitalist environment. While these programs stand to challenge epistemological centering through (re)centering the practice of STEM educational outreach between Indigenous and Western epistemologies, they may still contend with the consequences of their current centering in a broader, Western capitalistic frame.

That being said, there is an underlying transactive nature to these arrangements, reflective of an expression of agency by communities in pursuing educational technological development collaborations, despite their ties to powerful actors. Communities, aware of these ties, question the organization's capacity to confront powerful corporations. Nevertheless, the communities' willingness to engage with Geering Up suggests a transactive relationship between communities and corporations, with Geering Up serving as an intermediary. Although a critical view of this transaction could foreground whether it is a just part of the process of engagement, this underserves the rationale of communities as being informed decision makers. Thus, the contrast of potential exploitation and the pursuit of some form of community and personal empowerment by Indigenous communities in light of their embeddedness in the broader cultural, social, and

economic milieu suggests additional theoretical machinery to describe these arrangements within a postcolonial computing framework.

### *Expressions and Circulations of Power*

The process of cultural integration represents a space of negotiations where the output is integrated curricula, and is an arena where power circulates between and around different actors. First, Indigenous communities have a transactive resource key to the integrated curricula at their disposal in the form of cultural expertise, which educators negotiate to get access to in order to mitigate their own lack of cultural expertise. Communities, interested in the Western STEM education that the educational organization offers, negotiate with the educational outreach program. Knowledge keepers and elders represent their own community's cultural outlooks, serving as the agents of an essential resource to enable the process of cultural integration. Although there is no hard and fast rule that states that the educational outreach program needs to incorporate Indigenous cultural material, lack of cultural knowledge is a source of anxiety for the process, indicating the degree to which educators view cultural knowledge as a valuable resource.

On the other hand, power circulates in such a way that is outside the control of any of these particular actors. First, Indigenous community embeddedness in the much larger Canadian nation places them within an economic system geared towards a global capitalism. In response, Indigenous communities invite the educational organizations, with the goal of providing their students and youths with the tools to survive and thrive within the Canadian society and its system of cultural norms. This in turn supports the continued centering of STEM education within a Western cultural aesthetic. Thus, culturally integrated STEM, however valuable, is not necessarily one of the key factors spurring communities' interest in STEM outreach.

(Re)centering educational outreach between Western and Indigenous peoples require an extensive level of commitment over time, but the genesis of these relationships do not require a commitment to this process.

Second, significant financial disparities within this arrangement exacerbate the availability of educational resources within the negotiating space, disparities that are acute in computing education. Since transporting computing resources is difficult, the organization is forced to depend on what the community has locally available. This can be inconsistent, especially in poorer or more remote communities, many of which are First Nations communities. While ‘unplugged’ activities are valuable, it illustrates that the current state of computing lessons appears to be driven less by what cultural aspirations that communities have and more by what resources are even available, if at all.

The challenges to deeper engagement with cultural material can lend itself to a defaulting to a Western STEM model, based on feasibility (response to resource limitations) and comfort (cultural distance, community valuing of the program even without cultural integration), thus assuming a Western ‘centering-by-default.’ This risks the unfortunate side effect of assuming an uncritical stance towards the cultural outlook represented in Western-centered STEM, rendering them as ideologies that hegemonically privilege a Western view over others (Freedman, 2003; Hawkes, 2003; Zheng & Stahl, 2011). What this suggests is a deeper purpose for (re)centering through cultural integration as a counter to this hegemonic process by bringing to the fore the culturally imbued nature of STEM as being in an ongoing discourse with Indigenous cultural outlooks. Sultana & Ahmed (2019) point out that the sites of HCI can serve to combat ideological hegemony. In this study, we extend this belief by illustrating that hegemony can also be combatted within the process of design as a critical endeavor as well.

## **Enriching Design Scholarship**

In the following section, we will enrich postcolonial computing scholarship through key themes derived from designing a culturally-integrated curriculum. These will include incorporating a notion of resiliency, embracing politicizing as integral to cross-cultural design, and challenging the centering as an ultimate end-goal of design and development.

### ***Incorporating and Internalizing Resiliency***

In the conclusion of the previous section, we argued for the role cultural integration can play in dismantling Gramscian (Gramsci & Hoare, 1971) notions of ideology/hegemony, identifying a mechanism through which agency can be applied in protecting a communities' interests. Within postcolonial theorizing and contributions of critical theory there is room for a greater emphasis on the active role that First Nations communities undertake today in defining their own destiny. While such perspectives are subtly infused in scholarship, and often serve as the unstated goals of cultural integration research, more explicit theorizing is possible. These additional theoretical mechanisms might further structure engagement and provide a more nuanced a priori perspective about participants and communities. Postcolonial theory provides direct mechanisms for raising scholars' awareness of their place within coloniality (e.g. reinforcing economic dependence), but is less explicit about the *agency* of communities, particularly within a struggle against coloniality.

In terms of conceptualizing the expression of agency within these arrangements, an Indigenous community member emphasized the role of *resiliency* of First Nations, Inuit, and Metis peoples. Maori scholar Mason Durie's perspective on Indigenous resiliency is articulated in (Durie, 2006a, 2006b, 2006c):

“Superimposed on adversity and historic marginalization, indigenous resilience is a reflection of an innate determination by indigenous peoples to succeed. Resilience is the polar opposite of rigidity. It provides an alternate perspective to the more usual scenarios that emphasize indigenous disadvantage and allows the indigenous challenge to be reconfigured as a search for success rather than an explanation of failure.” ~Mason Durie (Durie, 2006a), as quoted in Valaskakis, Stout, & Guimond (Valaskakis et al., 2009).

Indigenous resiliency emphasizes a collective strength at the community level (Thomas et al., 2016). While perhaps not unique within the broad resiliency literature, this community level perspective articulates a conception of resiliency *built by Indigenous peoples for Indigenous peoples* (McGuire–Kishebakabaykwe, 2010). Resiliency as a formulation brings a shift in perspective wherein scholars come to internalize the view of Indigenous peoples as developers in their own right, and not just recipients or participants in Western-led projects.

Incorporating resiliency also highlights the significance of the *location* of design processes. As opposed to other forms of resiliency theory, the foundation of Indigenous resiliency theory is its place-based nature (McGuire–Kishebakabaykwe, 2010), reflecting the epistemological basis for Indigenous empowerment (Pierotti, 2011). Based on a sustained relationship with the land (McGuire–Kishebakabaykwe, 2010), Indigenous resiliency theory not only answers the *why* of technological design engagement, it also foregrounds the *where*: the relationship to the land as the basis of any work with Indigenous communities. Here, in discussions of the potential for cultural integration of computing education, community members highlighted the various proud cultural practices, historically based on a close social relationship

with their territory, such as geo-spatial mapping of fishing sites. Indigenous resiliency thus marries survival in the modern context, with a place-based notion of empowerment.

### ***Embracing Politicization in Design and Development***

It is common among technologists, HCI4D and ICTD scholars included, to avoid the political in their work (DiSalvo et al., 2010; Dourish, 2010; Gurumurthy & Singh, 2009). This norm evolves from the broader international development field, described as the “anti-political machine” (Ferguson, 1994), which is characterized by an inability to engage politics (Gurumurthy & Singh, 2009; M. M. Miller, 2014).

However, cultural integration of education illustrates the politically imbued nature of cross-colonial design work: it is inherently cultural work at a time when the line between the cultural and political is becoming increasingly blurred. Implementations of indigenization or cultural integration can have very real political consequences (Hamilton, 2018). The history of cultural assimilation as a geo-political weapon in Canada (for instance the residential school system as an assimilationist tool (MacDonald & Hudson, 2012)) indicates that harms to cultural integrity in turn harms sovereignty, and are therefore political harms. The anecdote shared by Keisha Everson of a lesson on totem poles being little more than stacking garbage highlights this obvious harm to cultural sovereignty.

The political implications of design practices can also occur within participating communities, as illustrated by the fact that identifying key sources of cultural capital like elders can be a potentially controversial choice that reveals political divides within a community. Furthermore, the snowball sampling method employed in this study also places this research along those same political lines. Through this lens, the task of cross-cultural design is inherently political. It is a process that imports pre-existing power relations, and implements, enforces, and

redistributes them in some way. Ekbja & Nardi (2016) make a case for the engagement of the political in HCI research, pointing out that without engaging the political aspects of their work, HCI loses its relevance. They describe a three-tier approach to importing political economy into HCI work, including *historicizing*, *contextualizing*, and *politicizing*. Politicizing under their schema is defined as “incorporating politics in [HCI theorizing’s] conceptual apparatus.”

The empirical data strongly suggests that co-designing curricula around cultural material is an inherently political act, in ways that are obviously extendable to designing cross-colonial, cross-cultural technologies. For one thing, the ill-fated totem pole highlights that a poorly constructed integration process harms cultural integrity, and within the context of cultural genocide in colonization, amounts to harms to sovereignty. Furthermore, working with communities taps into political structures within those communities, which can have political side-effects such as accidental exploitation of divisions. At the same time, co-design represents a space where communities can exert their own sovereignty, with cultural expression as a means of exertion, therefore redistributing of power. This expands on Searle & Kafai’s (2015) goal of challenging dominant Western narratives in colonization (p. 37).

Critically, this also entails that (re)centering technological design is likewise a political act. Embracing an awareness of the political in acts of (re)centering in design places the process within broader political forces, such as those within the community as well as geo-political relations, rendering designers particularly from the West as ad-hoc diplomats. This in turn means that designers inherit a set of political relations that contextualize their work. As the following discussion will also illuminate, the nature of computing knowledge itself brings its own set of self-perpetuating features, with implications for how we consider the discourse of cross-colonial, cross-cultural design.

### ***(Re)Centering the Knowledge Enterprise***

Computing can be conceptualized as a *knowledge enterprise*, represented by the institutions of knowledge (museums, libraries, archives) that stand as the symbolic center from which knowledge migrates (Dourish & Mainwaring, 2012). According to Dourish & Mainwaring (Dourish & Mainwaring, 2012) the computing knowledge enterprise rests upon a universalizing assumption that knowledge is unevenly distributed throughout the world, and that it is the responsibility of the holders of that knowledge to transmit it from centers to the periphery, explicitly suggesting the centralized nature of computing knowledge. It is this centrality that constitutes ubiquitous computing's universalist "colonial impulse." Colonial narratives extend beyond ubiquitous computing to ICT globalization more generally, encapsulating these fields within a shared narrative framework.

Implicit in any educational practice is that knowledge migrates, and Geering Up's activities are no different, encapsulating the narrative of knowledge migration and fulfilling the idea that it is the duty of institutions like UBC to assist in the migration of that knowledge from the center (e.g. Vancouver) to the periphery (e.g. a First Nations community in British Columbia), including ICT knowledge within STEM. When considered within the history of colonization between Western Canada and First Nations communities, this process embodies a collision between the colonial impulse of computing's knowledge enterprise and traditional colonization. Given that the ongoing damage to cultural integrity is a known consequence of traditional colonization (MacDonald & Hudson, 2012), it is imperative to view critically how the colonial impulse in technological education may contribute to further damage.

For one thing, there are limited examples and limited awareness of Indigenous produced ICTs, especially by those students who will become the next generation of builders. This



parallels the observed issue of racial representation of the educators, where limited Indigenous representation was connected to a limited awareness of Indigenous students' own potential, such as the stated hope for Indigenous students to "see themselves" in STEM. This concept of self-seeing speaks at least in part to the coherence of their own personal identity with the discipline itself. Due to representational divides, students must look to non-Indigenous cultural centers for inspiration, which limits the capacity to "see themselves" in the process.

Further, the aforementioned cultural distances and resource divides produce a resistance to Indigenous culturally-integrated material, stemming from the history of traditional colonialism in Canada, as both settler domination of educational institutions and resource divides from socio-economic marginalization are outcomes of this history (respectively). This arrangement begets the self-perpetuating nature of the colonial impulse: by centralizing and universalizing computing knowledge, it resists (re)centering. A parallel concept developed by philosopher Andrew Feenberg captures the practical design implications of this through a "technical code" (Feenberg, 2005) whereby a centrally constructed status quo maintains control over the shape and form of technological design. As noted by (Canevez et al., 2020), these forces are entangled with computing's empowering potential.

Since the colonial impulse depends on this centrality and universality, by corollary, (re)centering computing knowledge suggests a re-rendering of computing as a pluralistic epistemological endeavor. Guidance for the decentering aspects of this endeavor can be found in the work of decoloniality scholars like Walter D. Mignolo (2007), who developed the idea of 'epistemic delinking' as the theoretical basis for decentering. This necessitates a radical rethinking of the shape, form, and epistemological perspectives that produce computing

technologies, and is a rethinking that occurs in outside of the center of computing's knowledge enterprise ('border thinking').

Decentering of power/knowledge (in the Foucauldian sense (Foucault, 1972)) in computing appears to have implicit weight within the scholarship of cultural integration of ICT education, as the very notion of culturally integrated ICT education is based on the awareness of the transfer of social and cultural factors that occurs during the transfer of ICT knowledge (Duveskog et al., 2003; Tedre et al., 2006) as well as the inseparability of culture and technologies (Philip et al., 2012). Maja van der Velden (2013) directly argued for the 'decentering of design' when examining the absence of an 'indigenous knowledge' page on Wikipedia, suggesting the advantage of other modes of archival structuring that illustrate the possibilities of decentering the popular encyclopedia's design. Crucially, they claim that by "decentering the position of the expert designer and her knowledge, negotiations over who can be a designer come to the foreground" (p. 313). Sultana & Ahmed's (Sultana & Ahmed, 2019) exploration of witchcraft likewise critically viewed the centrality of design legitimacy.

However, while decentering is only part of the equation, full (re)centering forces us to ask *where technologies then come from, once technologies have been decentered*. The push and pull of progress within ICT globalization as reflected within the pitfalls and potentials of designing culturally integrated Indigenous ICT education within this case study illuminates that the answer to this question exists beyond merely the connection between culture and technology, and must contend with what the end-goals of cross-cultural development in design and education ought to be within the broader social, political, and economic context of computing knowledge itself.

### **Implication for Designers (Re) Centering Design**

Although much of the scholarship on (re)centering Indigenous culture in education and design explicitly seeks to move the center to more fully encapsulate the Indigenous viewpoint often underserved or outright ignored in these practices and institutions, what emerges empirically from programs like this that seek cultural integration is that the (re)centering that occurs suggests a situatedness in-between two cultural centers. Many of the challenges that emerged in the process of integration stemmed from the Western-centered embeddedness of both Geering Up (whose internal composition reflected this as well) and K'omoks First Nation. The result was an in-betweenness by design: curricula and lessons produced in this manner bear the hallmarks of Indigenous cultural material, but are shaped likewise by the challenges of Western educators and designers in working with cultural material largely unfamiliar to them. Artifacts, whether they are curricular or technological, designed this way therefore do not bear a (re)centering on Indigenous ways that the extant literature emphasizes as essential, but rather they are a (re)centering on the middle ground between Western and Indigenous.

For designers with a postcolonial orientation, this casts a light on how we think about the relationship between representation and how technologies are centered, especially as they stand to impact the shape and form of these technologies (Feenberg, 2005). While conceptions of (re)centering, whether it's in education or technology, in the popular discourse are framed between the Western and Indigenous poles, resulting artifacts bear out a more complex picture, existing on a gradient between these poles. Subject to (re)centering initiatives in contrast with the self-perpetuating centrality of computing knowledge produces cultural hybrids. Therefore the implications of this insight for designers is located in the hybridity of designed artifacts, as even within initiatives to maximize representation and co-design with distinct cultural

communities, the mere context of computing's enterprise impacts processes and in turn results. This insight does not refute the importance of (re)centering on Indigenous ways with regards to design in postcolonial contexts, but rather seeks to suggest that hybridized practices like these are contributing to novel hybridized notions of culture, which are in turn 'baked into' the resulting artifacts from the design process.

### **Concluding Remarks**

In this paper, we explore the shared space of cross-colonial, cross-cultural design, drawing on empirical findings of an educational outreach program designing culturally integrated curricula with Indigenous First Nations communities in British Columbia, Canada. In particular, we asked and answered two questions: a) *what can cultural integration of non-formal ICT and STEM education and postcolonial computing perspectives learn from one another?*; and b) *what do insights gleaned from cultural integration of ICT curricula and postcolonial computing suggest about the impacts of the colonizer-colonized relationship on technological design?*

Towards the first question, we applied a postcolonial computing lens to STEM and ICT integration. In doing so, we provided an empirical depiction of the process of cultural integration and resource impacts (social, educational, and technical) that framed postcolonial computing discussions on a) the generative nature of culture in these practices; b) identified alignment with powerful actors in these practices and their potential to impact cultural integration, laying the framework for a deeper exploration of community agency in design practices; and c) conceptualized the operation of power within the integration process. Then, we sought to enrich postcolonial computing scholarship through these empirical findings, providing a) an argument for resiliency as an orientation of design work, b) an argument for the embrace of the political,

given the unavoidably politically imbued nature of cultural and community based work, particularly with Indigenous communities, and c) a support of decentering orientations in cross-cultural, cross-colonial design work, motivated by the collision of computing's colonial impulse and traditional colonialism. We believe that these offerings lend scholars in both educational and technological design greater granularity in conceptualizing their work within broader colonial frames.

Towards the second question, this study illustrates that colonizer-colonized relationships in some contexts are increasingly working towards cohesive projects, enabled by the close, often overlapping, proximity of these sides, such as is the case in North America. While a welcome development, the process highlights the historical consequences that exist uniquely between colonizers and colonized, such as the social ills and oppressions persisting today, with related consequences for the centrality of computing and its self-perpetuating nature. Necessary contention with these issues by designers during the process of design leads to a hybridized result. This complicates the (re)centering discussion, forcing designers beyond the simple two-pole discourse between Indigenous and Western centers. This insight ought to more accurately speak to the experience of designers working in cross-cultural contexts in the global north.

In closing, we note an immediate outcome of this research was the co-creation of a culturally integrated lesson with K'omoks First Nation, which hopefully leads to further explorations in the future. While this is indicative of a successful co-design endeavor, it represents just one small step towards a more just set of epistemological power relations, and one that in its ultimate form may require the radical (re)centering of institutions in both education and tech development and incorporation of the implications of undeniable hybridity on where this (re)centering ultimately takes us.

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