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JON CORBETT

First, as is customary in my *nehiyaw*-Métis heritage, I will introduce myself, who I am, and where I am from.

tawaw, *tânisi*! Welcome, and hello! Jon Michael Robert Corbett *nitisiyihkâson ekwa niya nehiyaw-âpihtawikosisân*. My name is Jon Michael Robert Corbett, and I am *nehiyaw*-Métis registered with the Métis Nation of Alberta.[1] I was born in Edmonton, Alberta, Canada, to Sharon Joanne Corbett (née Hadley) and Robert Richard Corbett. My father and paternal grandparents, *nôhkomipan*, Ida Marie Corbett (née Richard) and *nimosômipan*, James Duncan Corbett, were from The Pas, Manitoba. *nôhkomipan* Ida *nehiyaw iskewew ekwa nahkaw iskwew*. My (late) grandmother Ida was *nehiyaw* and *nahkaw*.[2] My (late) grandfather James (aka Jim), was a descendant of English nobility from Shropshire, England. My late maternal grandmother Domka (Dora) Hadley (née Abramic) was Ukrainian, and I know very little about the heritage of my grandfather Charles Rufus Hadley, only that he was at least a 2nd generation Canadian and that the Hadley surname originates in England.

I currently reside in Kelowna, British Columbia, Canada, on the unceded territory of the Syilx Okanagan people. I have a BFA in Art and Design from the University of Alberta and an MFA from the University of British Columbia (Okanagan). I am completing my Ph.D. in Digital Humanities at the University of British Columbia (Okanagan). I am also a newly hired Assistant Professor at Simon Fraser University School of Interactive Art and Technology in Surrey, BC. I am a member of the Association for Computing Machinery (ACM), the American Indian Science and

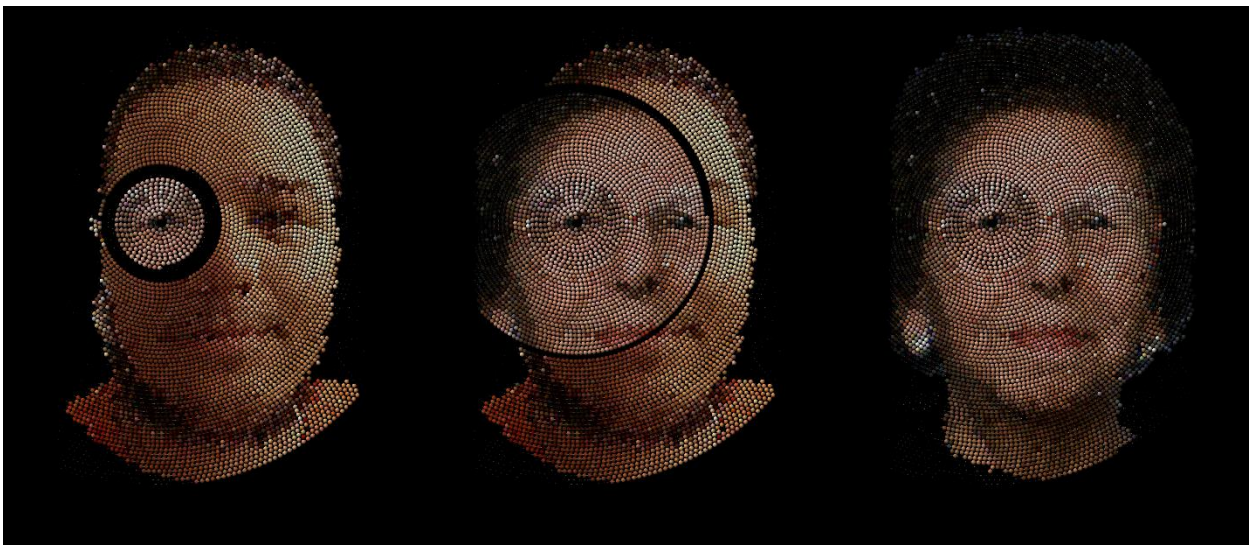
Engineering Society (AISES), and I am an Advanced Research Affiliate with the Humanities and Critical Code Studies Lab (HaCCS) at the University of Southern California.

My creative research has always been autobiographical, drawing from personal narratives and interactions with identity-building through cultural experiences. My methodological framework has always been rooted in self-reflection, identity, and story-based knowledge. For Indigenous people, story is integral to being. Jo-ann Archibald's (Stó:lō) "storywork" framework (Archibald et al.) emphasizes the "work" aspect of storywork as a key to understanding stories as serious forms of knowledge that are vitally important to Indigenous pedagogy. In *nehiyaw* culture, Neal McLeod describes our oral traditions as preserving our ancestors' "collective memory" (McLeod) through living, organic, and temporally fluid stories. Following these traditions in this essay, I tell *nitâcimowina*, my stories. For me, *nitâcimowina* transcends western notions of autobiography and autoethnography, as they include and emphasize my relationships with other people, places, eras, the spirit realms, and knowledges that developed through the lived experiences of my ancestors and their communities.

Storytelling as a research method takes many different forms in Indigenous research because different Indigenous peoples describe their relationships to story and self-identity in different ways. However, nearly all of them emphasize the sacredness of our identity as Indigenous people at the centre of our desire to resist Western research models as we seek to elevate our voices in contemporary research. For example, Paul Whitinui (Māori) describes "Indigenous Autoethnography" (Whitinui) as an Indigenous research method to address social justice issues by privileging and promoting Indigenous voices in qualitative research. Similarly, Leanne Betasamosake Simpson (Nishnaabe) speaks of "*kwe*" as a research method (Simpson). *Kwe* is the Anishinaabemowin word for woman, but its translation to English does not recognize the emotional, spiritual, intellectual, kinetic, or land-based knowledge contained and understood in

the word *kwe* (Simpson). Indigenous researchers employ these perspectives of story and identity in our research methods using our own cultural understandings of stories. These understandings may differ across Indigenous cultures, but their most significant difference can be seen in how they translate to western[3] notions of knowledge. In English, we often speak of the word story as anecdotal. For Indigenous people story is truth, and it is how we relate to and understand the world and our future, present, and past.

I will reflect on my digital artwork *Four Generations* (2015) and narrate how this work developed as a digital translation of my own Indigenous cultural praxis. From there, I explore how I transitioned my computational approach from logic to metaphor and share my responses to public discussions and academic critiques, contemplating this work in different knowledge domains. Finally, I express how these external investigations and insights from others have changed my approach to computing and (re)shaped my identity as an Indigenous artist and computer programmer.



Corbett, Jon. Four Generations (three single frame details). 2015. Computationally beaded portraits; Single channel digital video. Indigenous Art Centre, Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC), Gatineau QC.

The Work of *Four Generations*

Four Generations is a digital media installation I coded that computationally generates portraits of my Indigenous lineage using 3D-generated beads. The individual portraits are of my grandmother, father, myself, and son. Initially exhibited in my Master of Fine Art exhibition at the University of British Columbia in the summer of 2015 as *Generations*, this work was then curated for the *Transformer: Native Art in Light and Sound* exhibition at the Smithsonian National Museum of the American Indian (NMAI) in New York City from November 2017 through January 2019. *Four Generations* was also included in the Contemporary Native Art Biennial (BACA), 5th edition exhibition titled *Kahwatsiretátie: Teionkwariwaienna Tekariwaiennawahkòntie* \ *Honoring kinship* in 2020, and now resides in the collection of the Indigenous Art Centre, Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC).

The Origins of my Digital Beadwork

Four Generations evolved from a simple digital tool I wrote to help me create digital beading patterns from photographs into an animated generative work that metaphorically represents the transfer of intergenerational stories and knowledge.

The initial program I wrote used simple looping algorithms to create rows of beads based on a photograph. The program starts by reading a digitized photograph from the top left corner. It selects a random colour from a square matrix of pixels at each location, creates a neutrally-coloured 3D sphere, applies the chosen colour to the sphere, and then places that sphere onto a clean canvas in the computer's memory. Moving left to right, row by row, the program plots beads until it reaches the bottom right corner of the photograph and then saves the new beaded image as a digital file that can be viewed and printed. I would run this program ten to fifteen times because each image would be different due to the random selection of colour for each pixelled bead.

It was deliberately built to be a simple, time-saving utility application. From this output, I could decide which image I liked the best, print it, attach it to my material and bead the pattern without considering colour choices or placement. Beading is highly meditative. One of my mentors, Sherry Farrell Racette (Timiskaming/Métis), describes beading as a form of prayer that "produces introspection, wistfulness, and other thoughts, images, feelings, and sensations" (Garneau). While I beaded, I would think about the code, imagining myself as the program doing the colour decision-making and sewing each bead in place. Then, at the end of each row, I would move down a row and repeat my beading in the opposite direction, moving from right to left. After a dozen rows, this process of physical beading seemed to remove itself from the code because, in the program, the algorithm stopped at the end of each row, returning to the leftmost column to start beading the next row. This difference in actions between my physical beading and the computer program's loop design transformed how I considered the role of the program.

The first significant change I made to the program was to rewrite the loops to my process of progressing a row down and looping back to the beginning. Though this rewrite meant I intentionally changed the algorithm to be inefficient, I also saw it as more reflective of life. This switch in the code marked when I stopped thinking of the program as computational instructions and started thinking of the programming code in metaphor.

Coding Metaphor

The computer follows instructions in a very linear fashion, which, when combined with time, does not necessarily fit an Indigenous worldview. Adding to these challenges, I wanted to make my metaphorical relationships in this digital work explicit. For example, as I was working with family portraits, I saw each bead as a “day in the life of.” We are made up of the knowledge and experiences of each day until we pass, and as we live, we also pass this knowledge on to the next generation. *Four Generations* has 34,859 beads across all four portraits, representing the exact number of days my grandmother lived. When one animated portrait completes, it starts to un-bead, replacing each bead with a new bead for the next portrait, symbolizing the passing of knowledge from one generation to the next.

Generally speaking, computers are very adept at speed and precision. However, from a metaphorical and cultural viewpoint, these are significant challenges because these concepts oppose my *nehiyaw* teachings. Though the so-called “best” or “most efficient” loops meant I could see my result faster, it also caused the fracturing of my digital image output into separate individual lines of beads. This fracturing meant I was conforming to the design and language of the computer instead of having the computer understand how I wanted to process the imagery. Metaphorically, this conformity reflects Canada’s residential school system, which forcibly denied students from using their heritage language and cultural practices. I did not want to sacrifice my

nehiyaw language, cultural teachings, and practices to acculturate to western ways of doing so that I could express my *nehiyaw*-Métis identity in the digital world. Therefore, I added a digital "thread" to join the screen objects together. It is symbolic of "healing." It binds together the digital objects in a meaningfully Indigenous way, deliberately disregarding efficiency and healing the fracture caused by the system's design.

This shift in my conceptual computing model replaced my interest in replicating digital imagery with hide, sinew, and glass. Instead, it sparked an eagerness to "teach" the computer how to bead and how to use culture as an interface to code representation. I wanted to imbue the computer with the cultural metaphors and knowledge I draw from when working with physical media.

When I finally arrived at (re)coding *Four Generations,* I was intent on breaking and rewriting as many computational rules as possible. For example, I introduced "smudging" as a computational method. Smudging for *nehiyaw* people is a ceremonial practice involving burning a medicinal herb such as sage or sweetgrass and using the smoke it creates to "cleanse" or "purify" the individual. I digitized this practice. My first line of code is now *tisamân(); or tisamânihkew();*[4]. I created this function to explicitly clear the screen and cached memory, preparing the program for running. It is a digital representation of the cultural ceremony performed by many Indigenous groups in North America. I stopped using the row/column (x, y) coordinate system and started using a spiral-based "grid." I removed western math where I could, using string variables as numeric constants instead (for example, hand = 5, person = 20, and therefore 2*hands = 10). I ignored code optimization, choosing to code based on personal physical, cultural, and spiritual practices. Ultimately, I also stopped thinking of binary as opposing ones and zeroes and instead saw the machine as a unary device with *animate* and *inanimate* states of being.

Other authors have captured and explored this work, analyzing it in contexts of technology and time, anthropology, critical code studies, indigenizing computer pedagogy, and esoteric programming.

Time

I often describe beading in terms of contentedness. Beading has its own timeline in which I feel the passing of time is slowed and sometimes stops altogether. There is a duality to time. Time does not exist within the activity when I bead, but when I finish beading, each bead is evidence that time has passed. So, for a viewer, the translation of time to the real world is altered, and the terms of time are written into the program, transcending time in reality.

The Smithsonian's exhibition *Transformer: Native Art in Light and Sound* was an experience that highlighted where digital media distinctly intersected with time and Indigenous representation. In her accompanying article *Art that Moves*, co-curator Kathleen Ash-Milby (Navajo) highlights *Four Generation's* "constant motion [of the] slow spiral" (Ash-Milby) in the build-up of digital beads on the screen. Time is a metaphor I had consciously coded, intentionally slowing the computer down to a speed that is a fraction of what the computer can accomplish. In actual speed, it takes the computer a few seconds to render all 34K+ beads. Though the slowed-down version places about six beads per second on the screen, the slower speed allows viewers to contemplate and appreciate that a completely rendered image takes time to develop. At this speed, all four portraits take an hour and a half to render before repeating. Once the portrait of my son completes, it un-beads and restarts the beading of my grandmother's portrait. Although we have the technology to accommodate immediate gratification and delivery of digital imagery, Indigenous perspectives recognize the importance of time and the cyclical nature of life. The motion and time of *Four Generations* are perpetual. It does not just end when the program ends. It

begins anew. And because the program is generative, each subsequent portrait will never be the same as its previous iteration, thereby representing how time affects each new generation. You could almost say it is also intentionally timeless.

In its computational form, *Four Generations* has a deliberate start but no end; like the spiral I use a beading path. When the program starts, the first thing you see is an empty black screen. Then the first few beads appear, beginning the portrait of my grandmother. However, not all exhibition spaces have the equipment to run the full computer generative version, so I created a video version. The video was made with images of my father and myself in their normal state, but two complete cycles of my son and my grandmother so I could stitch together the end and beginning of the opening transition scene. This way, the screen does not start blank when run from a DVD or USB memory stick. The image opens with the full portrait of my son at the precise moment it has already started to un-bead itself, and the beading of my grandmother has started. This synchronous beading/un-beading starts in the middle of time, at a transition state in generations, when there is no true beginning or end. Though the digital information stream starts at the beginning of a file, the initial imagery pre-exists. You experience it from some point in its existence where time is irrelevant.

Anthropology

Four Generations as a source for anthropological study can be found in the single still image pulled from the moving context of *Four Generations*. The single still image of my grandmother's completed portrait has been used as an example in several print publications. One of the more stimulating texts it has appeared in is Jessica Helfand's *Face: A Visual Odyssey* (Helfand). *Face* is a critical anthropological exploration of the face in a literal A to Z visual voyage of cultural identity and *nôhkomipan,* my grandmother, can be found in chapter "H: Hereditary" (Helfand 81).

I find this focused view of *Four Generations* intriguing because it is presented in a larger context to which we can all relate. Though my work represents the *Hereditary* chapter, the faces in each chapter are less about the face as a subject and more about how we as a society use the face in different contexts to show or hide our identities. How we wish the outer world sees us dictates how we “decorate” and express ourselves. Our faces are often the starting point of our stories when we meet others. When meeting someone new, I immediately examine their facial features looking for tell-tale signs of their character. Do I see truth? Do I see pain? Do I see happiness? What are they showing me, and what are they not? I believe we all do this. It is subconscious and innate. This somewhat simple yet intriguing look at heritage through facial representation is profound, drawing on culture and lived experience. When I first saw *nôhkomipan* in this context, I felt proud, not because her image was used to represent *heritage*, but because *Indigenous heritage* was chosen to represent *heritage*.

Furthering anthropological investigations of digital indigeneity in my work, David Garneau (Métis) addresses these deeper connections to culture and heritage in his article *Electric Beads: On Indigenous Digital Formalism* (Garneau). In this article, Garneau critically examines *Four Generations* to provide insights on whether or not “Indigenous artists employ digital media differently than non-Indigenous artists?” Garneau also discusses the unique challenges that Indigenous artists face when working with digital media and technology. The Indigenous way of doing things always involves relationships. The word for relationship in *nehiyawewin,* is often referred to as *wâhkôhtowin* /waːhkoːhtʊwɪn/, and I understand it as a fabric woven of everything. Relationships bind us to everything else, the land, other peoples, the animate and inanimate, natural and supernatural, and even back to ourselves. Our relationships, stories and histories are archived and indexed within our creative products, and this relationality is key to resisting the colonial underpinnings of technology and digital media.

The digital "thread" I mentioned earlier that connects the beads on the screen illustrates these relationships. The beads are placed deliberately in relation to one another. They are strings connecting each bead that persist across generations as visual expressions of the continuity of knowledge and its binding to our cultural origins. Without this thread, the digital beads would just be floating in space. Even though the image would likely hold its own as an image, it would just be an image. Nothing would hold it together, and it would have only the mildest connections to my culture just because of the people depicted in it.

Another highlight Garneau brings forth is my resistance to conforming to an (x, y) coordinate system for plotting pixels on the screen. I changed my output from linear lines to a circling spiral to make the screen *my* space and (re)configure it according to my cultural teachings. Garneau equates this struggle against the systemic structures of the technology to Métis resistance to colonial gridding of the landscape and geometric planning of new cities in North America (Garneau). Occupations of our modern digital worlds, social media spaces, and virtual realities occur with the same colonial mindsets as the geospatial politics of our physical spaces. Our technicism and false beliefs about the neutrality of technology perpetuate colonial and euro-dominant cultural structures in digital spaces. Garneau's comments on the technological imperialism of our digital world and its impact on the surface of Indigenous digital art can also be viewed from inside the machine through critical code studies.

Critical Code Studies

Mark Marino's book, *Critical Code Studies* (Marino), provides a short history of the natural language elements found in computer programming, and he refers to my work, *Four Generations*, as an example of this push-back against "encoded chauvinism" (Marino 134). Critical code studies are concerned with examining code as literature and should be evaluated "within a sociohistorical context [and] analyzed using the [same] theoretical approaches applied to other semiotic

systems” (Marino 39). In this context, Marino frames *Four Generations* as a cultural intervention to make programming more accessible to communities whose cultural forms of expression are marginalized by the complexities of our socio-technological modernity.

I want people to understand this aspect of my work because it is the most hidden part, tucked away from view in the system’s bits and bytes of data. Additionally, my philosophies involve change but not necessarily replacement. I do not see myself dismantling western traditions to replace them with Indigenous knowledge. Nevertheless, I definitely privilege Indigenous worldviews and work towards establishing those Indigenous routes to knowledge that run parallel to and occasionally merge with western practices. This “undoing-redoing” is necessary to integrate additional alternative knowledge in the same way that the unbeading and rebeading within *Four Generations* is a metaphor for intergenerational knowledge transmission. Therefore, allowing culture to play a more significant role in computing design is necessary for increasing cultural knowledge in technology-based fields.

Introducing [Indigenous] culture to programming is not new. Outi Laiti (Sámi), unites ethnoscience and programming, creating the sub-field of “ethnoprogramming” (Laiti). Laiti notes that ethnoprogramming is not just about coding in non-English-based programming languages. It also includes increasing or improving cultural capacity in computing and culturally centring programming pedagogy. I agree with her belief that computer programming education for Indigenous youth, especially those raised in their ancestral culture, poses significant and unique challenges for educational institutions on a global scale.

Indigenizing STEAM Pedagogy

In the years since *Four Generations* was first exhibited at the Smithsonian NMAI, I have presented my work at conferences across multiple disciplines, including computer programming, language

revitalization, anthropology, and Native American cultural gatherings. All of these presentations were aimed at different audiences, and even though the content did not change much between them, each group had their own takeaways. Perhaps the most frequent groups that have invited me to discuss my work are non-profit organizations focusing on STEM and STEAM education and computing pedagogy for Indigenous students. STEM and its sibling STEAM are common monikers used in education to refer to the collective scientific domains of Science, Technology, Engineering, [Arts], and Mathematics.I argue that Indigenous STEAM education is a bit of a misnomer because Indigenous knowledge is wholistic (not holistic; see Absolon 2010). Excluding the "Arts" aspect from science education reduces the efficacy of STEAM's design and hampers collaboration between these domains.

Building meaningful relationships between cultural learning perspectives in modern science and technology, especially in middle and secondary school, is probably the most significant challenge these organizations typically face. In these presentations, it was not my goal to seek or encourage change but to expose intersections where Indigenous concepts in STEAM's subject material already exist. Before I presented at these workshops and conferences, I usually had a chance to listen to meeting attendees discuss their specific teaching initiatives and projects that use Indigenous knowledge or cultural practices. Of course, many of these Indigenous inclusions are needed in education and are extremely valuable to pedagogy. Yet, I was fascinated by how many of these advocates for indigenizing curriculum focused on finding Indigenous contexts to frame STEAM subject material without questioning the models(s) that STEAM programs are built on. I do not see myself as an educational professional, and this is not to imply that their models are flawed to start with. However, pondering my experience with the programming *Four Generations*, I realize I was just as guilty of this view of technology as culturally neutral and/or agnostic. In my case, I recognized the limits of what the system could offer me. Using a butter knife as a screwdriver can surely do the job, but is it the correct tool?

Assuming that a chosen framework is malleable enough to sculpt a suitable application or device that can meet the needs of the curriculum, it is also prudent to inspect if the framework is meaningful and question if it is appropriate. I found myself interrogating these same constructs. *Four Generations* made me question every character of code and every pixel on the screen. I scrutinized and questioned almost everything in my programming method and procedures to be satisfied that the tools I employed were appropriate and did not conflict with the cultural content contained within my code.

I also learned from listening to these educators that they had not encountered any obstacles preventing them from wiping their pedagogical slates clean as I did. Doing so would have meant giving up some great ideas and working models. But I also wondered how difficult it would be to start anew in specific contexts. For example, I reframed my model of computing science to fit my Métis heritage, which led me to ponder if I could do the same for engineering or hardware design. I can, and I did.

Though not directly related to *Four Generations*, it was a side project that came from a want to code in *nehiyawewin's* syllabic orthography. I created a *nehiyaw* syllabic keyboard to code with a very specific and culturally situated device. The most noticeable difference between my keyboard and QWERTY is the circular pattern created by the keys, unlike the linear three-row QWERTY layout we are all familiar with. But what is important is that I designed the keycaps using the thirteen “pole teachings” of the tipi or lodge and engineered the electrical circuitry of the printed circuit board (PCB) to reflect the Métis protocols of teaching/sharing circles.

The keycaps I made have thirteen vertical supports in their design, two at each corner, one that bisects each of the faces on the front, left, and right surfaces, and two that trisect the longest face of the back of the keycap. Much like the thread in Four Generations, this design was a way of connecting cultural teachings to the machine. Even though the vertical supports on the faces are

not structurally necessary, nor are they visible in the finished key, the fact that they exist is what is most meaningful. Their presence literally supports the language. The top of the keycap sporting the appropriate syllabic glyph is upheld by the meaning embedded in these vertical supports.

Naturally, when I finish describing how *Four Generations* changed my philosophy on computer programming and how I engage with the computer, I would get many comments on how simple I made it sound and how it opened up possibilities, followed by questions and requests for further guidance. How I see the world of computing today has so much more to do with understanding my growing knowledge of *nehiyaw* and Métis cultures than with the forty years I have spent programming computers. After hearing me speak, one organization's director even told me that his board was going to re-evaluate the English used in their mission statement and update the focus of their organization's values. The colonial systemic structures inherent in organizational structures, even Indigenous-run organizations, are easy for me to understand. I was raised as a fair-skinned, blue-eyed, middle-class, urban Canadian, so I was blind or at least numb to those oppressive structures. So, to have an organization stand up and say they would re-evaluate and possibly change their organizational philosophy based on my experience of indigenizing the computer through beading a picture of my grandmother is a very surreal and life-altering experience. Furthermore, the people I have met and events I have attended on Indigenous arts, technology, and pedagogy have opened my eyes to other academic fields that involve language and culture. I have seen how *Four Generations* can be used as a model for developing desperately needed tools for energizing cultures and communities and their knowledges, to foster revitalization to keep these cultures alive and stave off the need for "preservation."

Language Use, Cultural Maintenance, and Cultural Encryption

Of all the paths that *Four Generations* has created, the one I feel most touched by is the role it has played in language revitalization and how it has inspired other Indigenous communities to think ahead about the digital preservation and archiving of their cultural products, such as sacred stories and Elder knowledge, both oral and written. Recalling the “this” from my dream, I never saw *Four Generations* as a model for digital heritage-keeping.

Specifically, while I was attending the 2018 meeting of the American Indigenous Research Association in Polson, Montana, where I presented a poster on *Storytelling as a Computer Programming Language* using my work *Four Generations* as an example. I spoke to attendees about my ideas behind an Indigenous computing framework and how I believed using Indigenous stories as a programming language could help revitalize the language. I had two attendees come to me after my presentation to comment on how my model had the potential to do much more. Where I only saw the possibility that Indigenous youth interested in computer programming could be drawn to using their ancestral language for programming, they saw how such a structure could become a platform for the digital protection of traditional and Indigenous knowledge.

Their story was that many Native American communities in the United States distrust aspects of western society, especially academic and governmental institutions. They mentioned that communities they worked with had historically been “mined” for their intellectual property. Western academics came to their communities, learning their language, recording their stories, and writing down their Indigenous knowledge, which they then commoditized for academic and financial gain. As a result, these communities now refuse to share their cultural practices and languages with anyone outside the community. They told me I might have just created a solution allowing those communities to share their culture and language without exposing protected and sacred knowledge. They did not see my refunctionalization of the *nehiyaw* language as a

programming language as only supporting language revitalization. In *Four Generations,* they saw a potential solution for digitally archiving, encoding, and encrypting cultural heritage. My method of programming using stories written in code using my heritage language would satisfy their needs for knowledge protection while providing a creative way to share their culture with the rest of the world.

The computer's source code is obvious as a repository for language and story. Encoding the language and story as source code, by default, also makes the application an archive. The visual output is not just an encoded representation of the source code instructions. It is a form of archiving knowledge, joining other Indigenous record-keeping methods like wampum belts, totem poles, and petroglyphs. Of course, for me, these natural attributes of the system to encode and archive are not just happy accidents. Digital encoding and archiving are just new forms of Indigenous cultural practices that have existed for eons.

However, encryption, as an extension of encoding, had not occurred to me. When compiled, the human-readable qualities of the source code are replaced with machine code, and the application converts to a state the computer can execute. An application in this compiled state can be considered encrypted, though it is a one-way encryption. I see one-way encryption as particularly favourable for protecting Indigenous knowledge in modern society's openly shared and very social platforms. Sharing an executable file with anyone to run gives the executor of the file the right to view the output. However, decompiling the executable file in an attempt to extract the original language that created it is not possible, thereby safeguarding the cultural knowledge of the community.

My conceptual model(s) of computing that resulted from my coding of *Four Generations* has exposed to me that its framework is far more flexible and valuable than just a way of using ancestral languages to generate digital imagery. Furthermore, it has exposed disparities in language and comprehension between technologies and culture. And, rather than trying to wrestle

programming away from the hands of the English language, I found that my views of programming have infinitely improved through understanding the role of programming, the cultural forms it also possesses, and the people interacting with computers through their own languages.

Esoteric Programming (Esolangs).

An esoteric programming language, an esolang[5], is, in essence, an underutilized or underrepresented computer programming language. In many cases, esolangs are experiments created to explore the limits of programming language(s) and are often rooted in non-English contexts. Since rewriting the code for *Four Generations* using cultural metaphors in my coding structures, I discovered I was not the only one interested in the resistance fight against the English-dominated arena that is computer programming. I discovered the projects of Ramsey Nasser, esolangs, and the work of Daniel Temkin.

Ramsey Nasser created an Arabic programming language called “قلب” (“Qalb”), directly responding to English’s clutch on computer programming languages. Though he claims his language was a success functionally, he also states it ultimately fails because to be fully compatible in today’s coding world, it would need to interact with external libraries and application interfaces that are most likely written in English (Nasser, 00:03:43).

Similarly, Temkin is a new media artist, photographer, and programmer of esoteric languages. His award-winning blog esoteric.codes[6] is a fantastic curation of commentary on numerous aspects of coding and coding cultures, not just the languages themselves.

I met Daniel while presenting my work at the Humanities, Arts, Science, and Technology Alliance and Collaboratory (HASTAC) Conference in Vancouver, BC, in 2019. We had an excellent post-conference discussion that led to an interview for *esoteric.codes* (Temkin, “Interview

with Jon Corbett") and a segment in one of his articles for the online journal Hyperallergic (Temkin, "Programming Language Design as Art"). During one of our conversations, I was talking about my use of *nehiyaw* storytelling as a framework for my programming language, called "*âcimow*" /aːʧɪmʊw/ or "Cree#" in English. He asked me if the double coding in Cree# was intentional. I admit this did not occur to me initially. Did I intentionally create the language to be a story in itself? My initial reaction was, "no, it was not intentional." But then I remembered the dream I had when I was planning Cree#.

> I was sitting in a lodge listening to an Elder tell a story as my program transcribed his oration. A projector animated the story on the tent canvas all around those who had gathered to listen. Those in attendance could not see the code running, only the animated result. And this animation was "programmed" by his voice. At a break in the story, he paused, looked at me, smiled, and said, '**this** is what you build.'

So maybe it was subconsciously intentional. This dream occurred long before I met Daniel, on the eve before I started writing *âcimow* as a programming language. I still do not know what the Elder in my dream meant by "**this,**" but I often think of this dream in the metaphoric contexts of *Four Generations* and the digitized cultural traditions I built into it. The visual output shows viewers the image of my grandmother. At the same time, the computer code is a digitized version of my grandmother's life story hidden from view and only readable by myself or someone with access to the code. The code is a story that relates actions to the computer, just not necessarily about my grandmother, me, or our identities.

By way of example, coding in Cree# occurs in a storylike format that is syntactically formatted to be consumable by the computer. To rewrite the looping structure in *Four Generations*

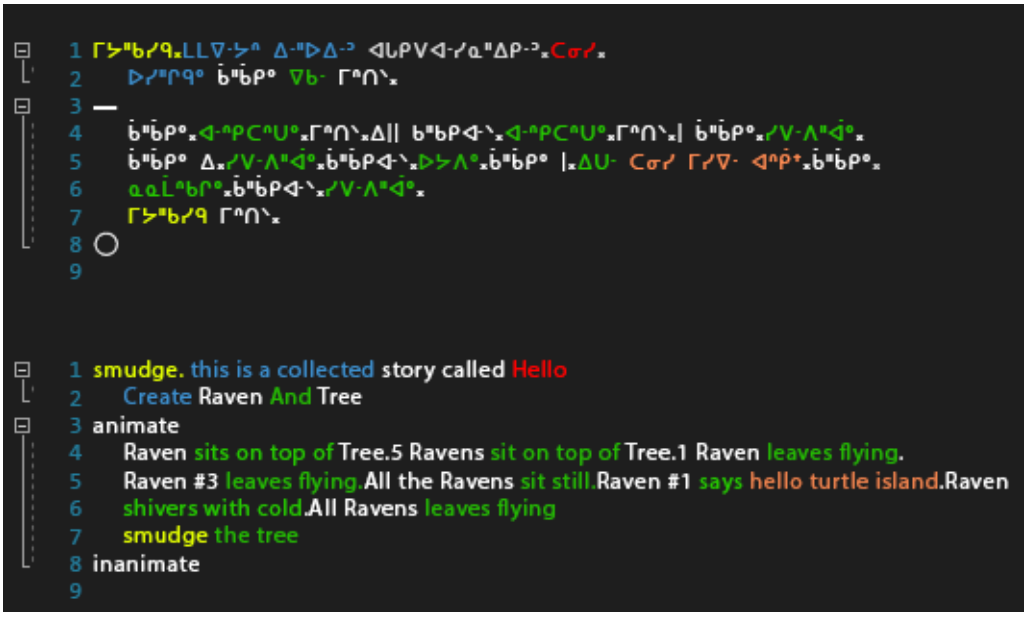
using Cree#, I use a metaphor of seasonal change, *pipona*[7] /pIpʊna/, the *nehiyaw* word for “winters.” Each line of code is written in a storylike sentence, and a simple code loop for placing beads would translate into an English pseudo-code that looks like this:

```
for each winter
        pick a colour of spirit berry[8]
        walk one step counter-clockwise
        plant the coloured spirit berry

        if no berries are left
          winter ends
        otherwise
          move to the next winter
        (if ends)
```

This code is a simplified example; additional comments only readable in the source code can provide further context to what is being coded. The intended output of this function is a digitally beaded image, similar to the ones in *Four Generations*. In this case, the code tells a story about picking berries, walking in the winter, and planting berries (presumably in the spring). It says nothing specifically about my grandmother or her life, but it does contain knowledge about identity, age, and the cyclical nature of life. Therefore, the story aspect of the programming language reads as a poetic narrative while simultaneously instructing the system to execute an instruction unrelated to the cultural comprehension of the statement. Though I have evolved the

Cree# language considerably, the storytelling syntax has become even more narrative, where the instructions in code are mirrored more literally on the screen.



```
ᒥᔅᑲᓯᐡᒪᒪᐁᐠᐣ ᐃᐨᐅᐃᐨᐣ ᐊᑌᑭᐯᐊᓯᐟᐡᐃᑭᐨᐣᑕᓂᓯ
    ᐅᓯᒥᕀᐤ ᑲᐤᑲᑭᐤ ᐁᑲ ᒥᐢᑎᐠ
—
    ᑲᐤᑲᑭᐤᓂᐊᐨᐢᑕᑢᐤᓂᒥᐢᑎᐠᐃ|| ᑲᐤᑲᑭᐤᐠᓂᐊᐨᐢᑕᑢᐤᓂᒥᐢᑎᐠᐃ| ᑲᐤᑲᑭᐤᓂᓯV-ᐱᐤᐊᐤᓂ
    ᑲᐤᑲᑭᐤ ᐃᓂᓯV-ᐱᐤᐊᐤᓂᑲᐤᑲᑭᐤᐠᐅᐯᐱᐤᓂᑲᐤᑲᑭᐤ |ᓂᐃU· Cᓂᓯ ᒥᓯᐁ· ᐊᐢᑭ⁺ᓂᑲᐤᑲᑭᐤᓂ
    ᐋᐋᒪᐢᑲᒋᐤᓂᑲᐤᑲᑭᐤᐠᓯV-ᐱᐤᐊᐤᓂ
    ᒥᔅᑲᓯᐡᒪ ᒥᐢᑎᐠᓂ
○


smudge. this is a collected story called Hello
    Create Raven And Tree
animate
    Raven sits on top of Tree.5 Ravens sit on top of Tree.1 Raven leaves flying.
    Raven #3 leaves flying.All the Ravens sit still.Raven #1 says hello turtle island.Raven
    shivers with cold.All Ravens leaves flying
    smudge the tree
inanimate
```

Corbett, Jon. Cree# code, story prototype example with english translation. 2020.

Conclusion

As I sit and write this reflection and observe how others have responded to and applied my conceptual and theoretical perspectives on culture and technology to their own domains of knowledge, I am struck by how a seemingly simple philosophical change can affect the kinds of changes that *Four Generations* has. I think *Four Generations* reveals the relationships between western and Indigenous cultures that previously seemed to be at odds with one another. Those relationships can be difficult to discern and describe. The critical evaluation of *Four Generations* I revisited here demonstrated that the theoretical model it represents can indigenize knowledge perspectives in multiple domains and has been a valuable source of inspiration for Indigenous and non-Indigenous scholars.

I initially set out to honour my family and my heritage. To celebrate my culture and explore how the capabilities of today's technologies afford culturally relevant artistic creation in

our modern techno-socio world. I am amazed and humbled by how *Four Generations* has become a seminal work in the art history of Indigenous digital art production. I am even more amazed at how this single work has affected so many other knowledge domains, including some I did not have space to include here, like digital feminism and more extensive critiques of racial inequity entrenched in digital technologies.

Four Generations has changed nearly every aspect of my artist identity. I found that *nehiyaw* cultural teachings involving things like reciprocity, interdependence, medicine and ceremony all have a place in computer programming and computing philosophies. I continue to listen to the tools and materials I use, both technological and traditional, as their conversations and relationships assist in braiding my western-Indigenous identity. I find it ironic that the evolution of my creative work marked by the creation of *Four Generations* was caused by a shift in my logic and computational theory. Now, when I engage in reclaiming my *nehiyaw*-Métis heritage through my artistic research, I am far more sensitive to how encompassing knowledges affect my role as a cultural producer. In a sense, my identities as a Métis artist, *nehiyawewin* learner, and computer programmer are one collective identity that has been beaded by those who have experienced and contemplated the intricacies of *Four Generations*.

Notes

[1] *nehiyaw* is the name of a First Nations heritage group more commonly referred to in English as Plains Cree.
[2] *nahkaw* is the *nehiyaw* Plains Cree name for our Eastern cousins the Saulteaux.
[3] Historically, proper nouns like “Settler” and “Western” have been used in scholarship alongside “indigenous” (lowercase “i”). As a supporter of a growing movement among Indigenous scholars, I intentionally opt to use lowercase for generic proper nouns like “settler” and “western.” This choice serves as a deliberate rebuttal to the power inequalities inherent in such naming practices, and emphasizes and amplifies Indigenous voices.
[4] *tisamân and tisamânihkêw* are *nehiyaw* words for “smudge” and “making a smudge”.
[5] See https://esolangs.org/wiki/Main_Page for more indepth descriptions and https://esoteric.codes/ for examples.
[6] https://esoteric.codes/

[7] In some *nehiyaw* communities "winters" is how you identify age. For example, I am fifty winters old.
[8] In *nehiyawewin* the word for "bead" is mîkis, which is similar to the word for berry "mînis". In *anishinaabemowin*, the word for bead is "manidoominens" which literally translates as "spirit berry."

Works Cited

Absolon, Kathy. "Indigenous Wholistic Theory: A Knowledge Set for Practice." *First Peoples Child & Family Review*, vol. 5, no. 2, 2010, pp. 74–87, https://doi.org/10.7202/1068933ar.

Archibald, J. A., et al. *Decolonizing Research: Indigenous Storywork as Methodology*. Zed Books, Limited, 2019, https://books.google.com/books?id=KVrHugEACAAJ.

Ash-Milby, Kathleen. "Art That Moves." *American Indian Magazine*, vol. 18, no. 3, 2017. *www.americanindianmagazine.org*, https://www.americanindianmagazine.org/story/art-moves.

Garneau, David. "Electric Beads: On Indigenous Digital Formalism." *Visual Anthropology Review*, vol. 34, no. 1, 2018, pp. 77–86.

Helfand, Jessica. *Face: A Visual Odyssey*. MIT Press, 2019.

Laiti, Outi. "The Ethnoprogramming Model." *Proceedings of the 16th Koli Calling International Conference on Computing Education Research*, ACM, 2016, pp. 150–54.

Marino, Mark C. *Critical Code Studies*. MIT Press, 2019.

McLeod, Neal. *Cree Narrative Memory*. 2000.

Nasser, Ramsey. *A Personal Computer for Children of All Cultures*. https://www.deconstructconf.com/2019/ramsey-nasser-a-personal-computer-for-children-of-all-cultures. Deconstruct Conference 2019, Seattle, WA.

Simpson, Leanne Betasamosake. "Kwe as Resurgent Method." *As We Have Always Done: Indigenous Freedom through Radical Resistance*, University of Minnesota Press, 2017, pp. 27–38.

Temkin, Daniel. “Interview with Jon Corbett.” *Esoteric.Codes*, 30 Mar. 2021, https://esoteric.codes/blog/jon-corbett.

---. “Programming Language Design as Art.” *Hyperallergic*, Jan. 2022, https://hyperallergic.com/701981/programming-language-design-as-art/.

Whitinui, Paul. “Indigenous Autoethnography: Exploring, Engaging, and Experiencing ‘Self’ as a Native Method of Inquiry.” *Journal of Contemporary Ethnography*, vol. 43, no. 4, 2014, pp. 456–87, https://doi.org/10.1177/0891241613508148.