Doctoral Dissertation:
Developing, Implementing, and Evaluating School-based Environmental Education Programs that Braid Indigenous and Western Science

by

Julia E. Palozzi

BSc, University of Toronto, 2014
MSc, Western University, 2017

A Dissertation Submitted in Partial Fulfillment
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We acknowledge and respect the Lək̓ʷəŋən (Songhees and Esquimalt) Peoples on whose territory the university stands, and the Lək̓ʷəŋən and W̱SÁNEĆ Peoples whose historical relationships with the land continue to this day.

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Abstract

Evaluations are essential tools for program improvement, especially in environmental education that integrates Indigenous and Western Science. The aim is to enhance knowledge, skills, and awareness, fostering participation in environmental stewardship through the respectful weaving of both Indigenous and Western Science practices and principles. In this dissertation, I explore the development, implementation, and evaluation of environmental education programs that integrate these two knowledge systems within school-based settings. The introduction outlines the research context, my positionality, and the collaborative relationships that enabled this research. Each data chapter corresponds to a phase of the program lifecycle—development, implementation, and evaluation—grounded in principles of developmental, collaborative, and culturally responsive evaluation. Chapter One presents a checklist for developing programs that braid Indigenous and Western Science, written in a narrative style to synthesize my experiences and highlight key learning moments. Chapter Two examines program implementation across two distinct curricular contexts, discussing strengths, challenges, and trends identified through process evaluations. In Chapter Three, I analyze program outcomes, focusing on students' environmental knowledge, attitudes, relationships with nature, and engagement with materials. I use both quantitative and qualitative methods to explore the main themes from the data. I conclude with reflective exercises that delve into how principles of Indigenous education and developmental evaluation appeared throughout my research. By sharing my experiences in navigating program development, implementation, and evaluation in environmental education, this research contributes to a growing body of literature addressing the ecological crisis and the dismantling of colonial educational structures.

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Finally, many, many həyšxʷq̓əs to my colleagues and students at the Nation—I cannot emphasize enough what a pleasure it has been working and learning together, and what a source of comfort the community has brought me as I toiled away at my dissertation. I feel blessed with the opportunity to apply what I've learned and excited to continue our journey together.

Dedication

To be guided by fragrance is a hundred times better than following tracks.

- Rumi

I dedicate this work to those embarking on new and uncertain paths. May you trust what you feel instead of fearing what you don’t yet know.

Introduction

0.1 Background

I began my PhD journey by developing a program focused on cultivating resilience in youth. Trained as a trait-based ecologist during my MSc, I learned how plants can shape their environments through their characteristics to support their own growth, and that of those around them. I believed this concept could be imparted to youth. I began wondering about trait expression and, subsequently, developmental plasticity—the ability of an organism to change its development in response to environmental conditions, as discussed by evolutionary biologist Mary West-Eberhard (2003). Leveraging developmental plasticity could provide a survival advantage, especially given the high incidence of child maltreatment experienced by Canadians (Bader & Frank, 2023). However, my aspirations proved complex and challenging to implement. After a series of setbacks, I found myself back at the drawing board.

Although I initially knew little about Indigenous ways of knowing, I was drawn to their resonance with my own experiences of learning from nature. I sought to expose youth to worldviews that emphasized observing and working with plants and animals with the intention of learning—an inherently Indigenous perspective that aligns with systems thinking (Cajete, 2000; Lange, 2018). Although the thread of *development* remained, my PhD shifted focus from developmental plasticity to exploring *developmental approaches*, namely to design and evaluate environmental education (EE) programs that braid Indigenous and Western ways of knowing. I felt that EE as a discipline gave me the opportunity to work with youth and be of service in a meaningful way. Nature-based and outdoor educational programs, ideally, could contribute to raising awareness of or mitigating the ecological crisis while also creating culturally responsive science curricula for Indigenous learners.

The discipline of EE is increasingly recognized as a crucial approach to mitigate the environmental crisis (Reid et al., 2021). As discussed by Hancock (2019), today's world faces significant challenges, including climate change, sustainability, and the need for responsible environmental stewardship and heart-led science. EE has evolved from its early foundations, which primarily focused on raising awareness and fostering pro-environmental attitudes, to encompass a broader framework that includes enhancing knowledge, developing critical thinking skills, and providing opportunities for active participation in environmental stewardship and problem-solving across diverse contexts (Monroe & Krasny, 2016). This evolution has led to the integration of EE in various educational settings, including place-based and outdoor learning that physically connect youth to their environment; such experiential learning helps students better understand ecological relationships and interconnections (Monroe & Krasny, 2016).

According to Hunter & Richmond (2022), an increasing number of educators are recognizing the importance of incorporating Indigenous knowledges into environmental science education. This inclusion not only enriches the educational experience by fostering relational teachings that are often overlooked in Western frameworks, but also highlights the social implications of decolonizing educational spaces, as mentioned by Potawatomi Citizen educator Robin Kimmerer (2012). As mentioned by Siemens (2017), while these spaces have and continue to function as vehicles of colonization, they also possess the potential to become sites of reconciliation, enabling a critical examination and gradual dismantling of colonial structures. Braiding Indigenous and Western Science practices can lead to culturally responsive, holistic, and effective EE programs that are relevant to both Indigenous and non-Indigenous learners, and with thoughtful facilitation, can be successfully implemented by non-Indigenous educators (Kapykra & Dockstator, 2012; Snively & Williams, 2016).

Despite the potential of braided EE to foster meaningful growth and learning, it is essential to evaluate these programs. Program evaluation serves as a valuable tool that can translate the potential of EE into realized outcomes, provide mechanisms for assessing participants' experiences and program effectiveness, and can help programs adapt to shifting trends in EE (Anderson et al., 2022a; Monroe, 2010). Moreover, it offers checks to ensure that curricula uphold cultural responsiveness and allow for the implementation and refinement of culturally responsive evaluation techniques, particularly in Indigenous contexts, as noted by Anderson et al. (2022b) and Shepherd & Graham (2020).

Michael Quinn Patton (2011) champions developmental evaluation (DE) as an approach that emphasizes adaptiveness, flexibility, and collaboration, making it suitable for context-sensitive and emergent programs. These principles align with culturally responsive evaluation (Anderson et al., 2022b) and remain relevant across the program lifecycle of development, implementation, and evaluation. During program development, DE facilitates collaboration, flexibility, and reflexivity in shaping programming and curricula. The implementation phase emphasizes adaptiveness and real-time adjustments, while outcome evaluation assesses the impacts on participants based on specific evaluation questions and utilizing multiple data sources (Quinn Patton, 2011). DE has gained recognition in EE in recent years and is a natural choice for evaluating programs in mainstream school settings, which can be complex and uncertain (Anderson et al., 2022a; Drossman, 2024).

0.2 Dissertation Roadmap & Research Objectives

In this dissertation, I explore the development, implementation, and evaluation of six EE programs that braid Indigenous and Western Science across two distinct curricular contexts, primarily through the lens of DE. I adopt a holistic approach to the program lifecycle, examining each phase in dedicated chapters, with objectives outlined in Box 0.1. This dissertation follows a

manuscript-style format, with each chapter designed as a stand-alone publication. To avoid unnecessary repetition, essential contextual information—such as my positionality and the context surrounding school relationships—is presented only once, here in the introduction. However, there will be the same illustrative figures presenting program characteristics that will appear in multiple chapters. While there is no separate literature review chapter, relevant literature is woven throughout each chapter, where it is integrated into the broader context of my research and referenced accordingly.

The first data chapter presents a program development checklist, accompanied by a narrative based on my experiences collaborating with various members of the school community. This checklist addresses five key program components and offers questions and considerations for each. In the second data chapter, I focus on the implementation of these programs, providing process evaluations for the six programs in the Mature (two long-term programs) and Emerging (four short-term programs) contexts. Chapter Two also includes a discussion of the strengths and challenges of implementation within each context, and through the lens of DE, I offer an evolutionary perspective on program refinement over time.

The third chapter provides an examination of program outcomes, detailing how the braided EE programs influenced students' environmental knowledge and attitudes, relationships with nature, and engagement with material. I employed multiple methods—including quantitative surveys, qualitative student feedback, focus groups, open-ended survey questions, educator interviews, and practitioner observations—to inform these outcomes. Key themes were identified in the coding process, alongside novel findings and barriers to learning. Finally, the Conclusion chapter includes a synthesis of key findings, a reflection on how principles of Indigenous education (Cajete, 2010) and DE appear in each program phase, and a discussion of

main themes across all chapters.

Box 0.1

Objectives Associated with Each Dissertation Chapter

Chapter 1: Program development

Objectives

1. Develop and promote an evidence-based tool along, with supporting strategies, for creating and implementing school-based braided EE programs.
2. Provide guidance for educators—particularly those without strong pre-existing relationships with Indigenous educators and/or school communities—on how to develop EE programs with an IWS component through community-engaged approaches.
3. Offer a detailed, grassroots-level perspective on program development drawn from a three-year experience developing six braided EE programs in two distinct curricular contexts within mainstream schooling.

Chapter 2: Program implementation & process evaluations

Objectives

1. Integrate multiple sources of data and examine how these programs are implemented of with a focus on braided education that emphasizes experiential, outdoor, and community-engaged learning.
2. Compare and contrast implementation of braided EE programs across different school contexts, considering variables such as time, curricula, class size, resources, educator experience.
3. Identify key trends, strengths, and challenges in program implementation through integration of student and collaborator feedback and practitioner observations.

Chapter 3: Program outcomes

Objectives

1. Use multiple methods (e.g., surveys, focus groups, written responses, informal conversations, and student work) to assess the impact of school-based braided EE programs on students' environmental knowledge and attitudes, relationships with nature, and engagement with material.
2. Identify and analyze the factors that facilitate or impede learning

0.3 Researcher Self-Location

Positionality and self-location are essential processes for educators engaged in environmental and Indigenous education (Hunter & Richmond, 2022; Lowan-Trudeau, 2012). Hunter and Richmond (2022) emphasize the significance of self-location in EE that incorporates non-Western perspectives, highlighting that “knowledge is contextual and that lived experience and

knowledge cannot be disentangled" (p. 1066). The following self-location statement provides insight into my background, influences, and motivations for pursuing school-based braided EE programming as a non-Indigenous person.

I am a third-generation white settler from a middle-class two-household family raised in Toronto. My paternal grandparents emigrated from Abruzzo, Italy in the 1950s and settled in Tkaronto/Toronto within Treaty 13 Territory. My maternal grandparents settled on opposite coasts of Turtle Island (Tsimshian and Mi'kmaq territories) in the late 1800s, with mixed European ancestry from Britain, Italy, and Germany. I have an educational background in physical geography and wetland ecology, and some experience with developing youth programs in the non-profit sector. I identify as an autistic person with ADHD that stutters. I am also nonbinary, queer, and a survivor of complex childhood trauma. My intersection of privileges, trauma, and disability enables me to work with the communities I strive to serve and inspires me to make positive impacts in those spaces.

My ways of coming to know and understanding reality are a bricolage or interweaving of multiple perspectives that synergistically enhance my understanding (Denzin & Lincoln, 2011). My learning process involves constructing knowledge over time with the understanding that our personal experiences and beliefs influence perception of reality (constructivist epistemology, critical-realist ontology; Denzin & Lincoln, 2011). I gain deeper understandings from noticing connections between the physical and spiritual (dreams, visions, imagination), and through reflecting on ongoing interactions between actors (human and nonhuman) and their actions (relational ontology; Datta, 2015). A major source of my sense-making comes from valuing interdependencies, adopting multiple perspectives, and recognizing the responsibility of knowledge toward action (relational epistemologies; Bang et al., 2018). I often use nature-based

metaphors or analogies to enhance my understanding (systems thinking) and have gleaned many teachings through previous studies and work experience from wetland plants about resilience, adaptability, agency, and reciprocity. Being a neurodiverse learner, checklists and Western-style processes support my learning through adding structure and organization, and streamlining action; similarly, these kinds of tools have informed my research and practice.

In addition to the Knowledge Keepers and Elders I have engaged with in person throughout my learning journey, several local scholars have significantly influenced my work. Coast Salish scholars highlight practices that uphold Indigenous education on lək̓ʷəŋən and W̱SÁNEĆ territories, where our programs take place. These include showing respect for plant and animal ancestors, the land, and one another; learning from and with the land and community; engaging in observation and experiential learning; incorporating both Indigenous and non-Indigenous perspectives into the curriculum; grounding lessons with intentional openings; using storytelling (e.g., sharing positionality and introducing oneself to the land and each other); and fostering learning through sharing circles (Claxton & Rodríguez de France, 2019; Mowatt et al., 2020). The practices outlined by these scholars, along with the guidance of Knowledge Keepers, Elders, and community members encountered in this work, have directly informed the Indigenous Science practices woven into the programs described in my research.

However, scholars from across Turtle Island have also been instrumental in shaping a foundational understanding of pan-Indigenous Science approaches. Gregory Cajete (Tewa) has profoundly influenced my understanding of the multiple dimensions of the learner—physical, emotional, intellectual, and spiritual. In *Native Science* (2000) and elsewhere (2010), he emphasizes that true learning occurs only when teaching engages each of these dimensions and acknowledges the highly non-linear, individualized nature of the learning process which often

involves community, solitary reflection, and creative engagement with the land. Robin Kimmerer (Citizen Potawatomi) has transformed my perspective through her writings, particularly in *Braiding Sweetgrass* (2013) and other literature (2012, 2017), where she emphasizes themes of reciprocity and the importance of recognizing gifts in the world around us as a pathway to restoring relationships with the land. Another significant influence has been Mi'kmaq educator Marie Battiste (Potlotek First Nation), who shaped my understanding of learning as "nourishing the learning spirit." In her book *Decolonizing Education* (2013), she articulates how an innate guiding force—our spirit—embarks on a journey to acquire knowledge throughout life. I perceive this knowledge as being related to fulfilling one's life purpose, and I have felt this to be true on my own path. This journey involved an abrupt shift from science to education following a major turning point, during which I became more aware of the factors and events shaping my life and self. This newfound awareness inspired me to pursue heart-led work with youth, leading me to experiment with the positive youth development programs I described earlier in this chapter. These insights have deeply informed how I conceptualize my work. In the realm of program evaluation, Michael Quinn Patton (2011) has been instrumental in guiding my approach to developmental evaluation and program design, which emphasizes adaptiveness and flexibility.

0.4 School Contexts & Research Relationships

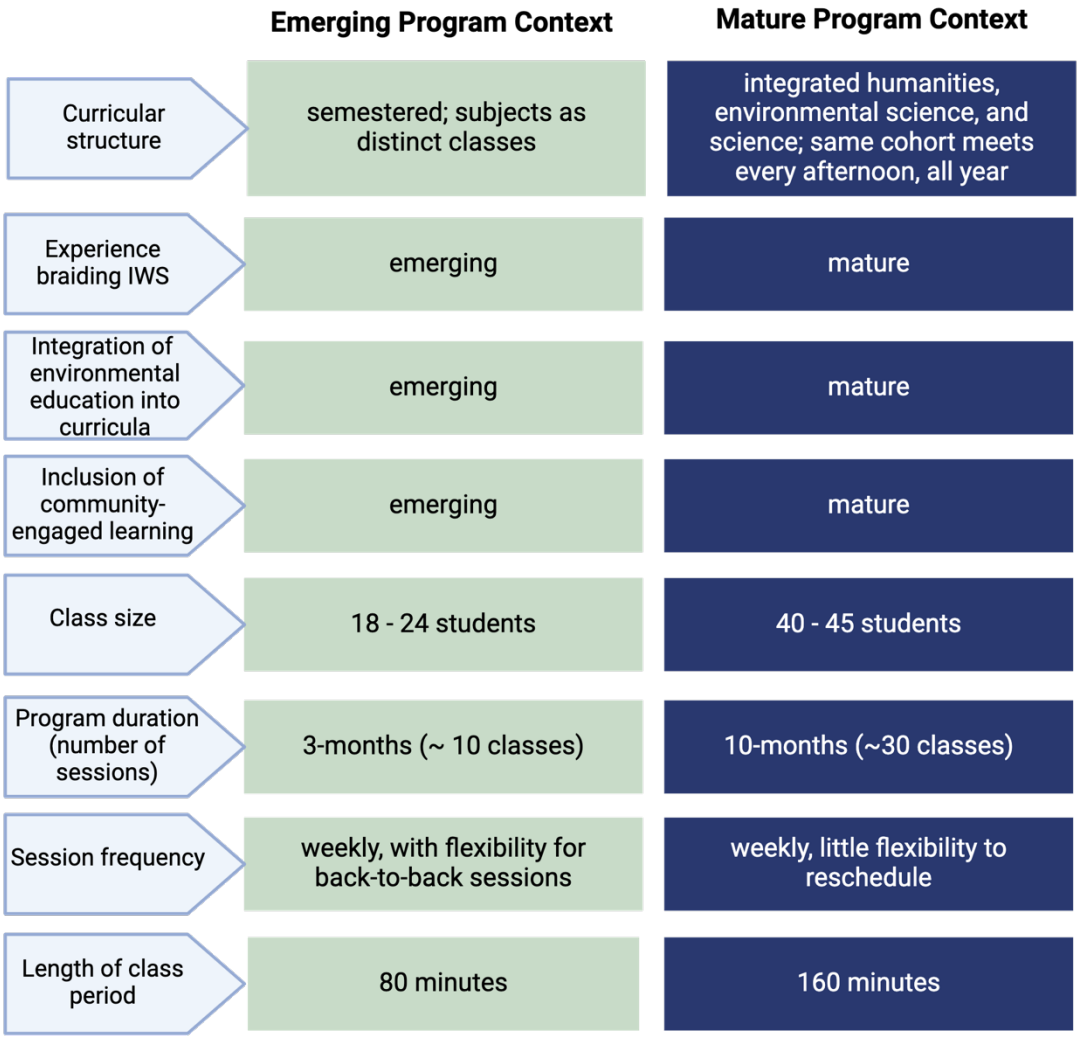
Chapters Two (implementation) and Three (outcome evaluation) examine programming within two key curricular contexts that I describe as "Emerging" and "Mature." These schools differ in significant ways, such as their history with EE, the extent of EE integration into their curriculum, experience with braiding Indigenous and Western Science, and their relationships with Indigenous educators (Figure 0.1). However, the schools were not intentionally selected for their contrasting characteristics. Instead, they became community partners organically as a result of chance and evolving relationships. The distinction between "Emerging" and "Mature" contexts

only emerged later, through reflective analysis of the implementation and evaluation process. It was through this reflective process that I recognized how these two schools represented contrasting curricular structures, providing a valuable opportunity to apply DE.

Before formal development began, my initial relationships to the educational community were facilitated through one of my supervisors at a local high school, which later became known as the “Emerging” educational context. In this setting, an Indigenous educator had encouraged a participating teacher to engage in the program, even though EE wasn’t yet integrated into the curriculum. During our closing interview, the teacher admitted that, without that encouragement, they likely wouldn’t have taken the risk of collaborating, which involved dedicating class time to the program. Around the same time, I connected with a curriculum developer through a community-campus hub liaison, who was instrumental in developing the Indigenous Science components for the pilot program in the Emerging context. From March to June 2022, I engaged in a participatory observational period, making nearly weekly visits to the classroom to build relationships and observe student learning styles. This teaching partnership evolved into a mutually beneficial collaboration that continued over two years, encompassing a one-week pilot (June 2022) and four short-term programs (September 2022 to June 2024).

Figure 0.1

Program Context Characteristics



Note. Characteristics of two school contexts where the braided environmental education programs were hosted.

The curriculum developer also connected me with other key collaborators, such as the district's Traditional Knowledge and Land-based Learning coordinator and the lead collaborator in the Mature context. In the Mature context, braided EE was already well established, but the lead environmental science teacher was nearing retirement. They saw our partnership as mutually beneficial, providing me with a research opportunity and offering them a way to ensure continuity in the program after their departure. From March to June 2022, I observed weekly

sessions, and in the next two years I took on a more active role assisting with curriculum development and instruction in year one, and mostly curriculum development with instructional support in year two.

In early 2022, I met with the Traditional Knowledge and Land-based Learning facilitator for the school district to discuss the goals of my research, identify areas of overlap, and explore potential collaboration. To deepen my relationships to community, I was encouraged to attend various community events. Over the following year, I participated in professional development days and workshops, which allowed me to engage with Indigenous educators and learn from local community members and Elders. During this time, developmental evaluation proved invaluable; as I implemented programs, I was able to make real-time adjustments based on local protocols and important cultural values learned from these experiences. In late 2023, I had the opportunity to collaborate more closely with a local community member after several conversations about potential partnerships, facilitated by funding opportunities tied to the Emerging context. This collaboration, marked by flexibility, allowed us to engage based on the timing and capacity that worked for both of us.

Finally, while not part of the formal research, my role as curriculum coordinator for a local First Nation's youth program from 2024 onwards was another important context for the application and refinement of my skills. This role, which involves collaborating with Indigenous staff to implement and refine literacy, numeracy, science, and art activities, further enriched my practice. Though separate from the research activities, the principles of braided education, and developmental evaluation were applied here, deepening my understanding of Indigenous pedagogy and collaborative program evaluation in an Indigenous context. Through the consistency of my role and these relationships in this setting, I learned firsthand about the

importance of relational accountability—how simply showing up and providing consistent support can fulfill a core need. These experiences working with and for the Nation emphasized the value of meeting colleagues and students where they are on their journeys and honoring their unique strengths.

As I explore in the Conclusion, developmental evaluation proved essential in adapting programming as relationships evolved. In line with the flexible and iterative nature of DE, different collaborators naturally faded in and out of the process as their roles, capacities, and contexts shifted over time. Such a dynamic allowed the program to evolve in response to emerging needs and new relationships, ensuring that programs remained relevant and responsive to both educational and cultural priorities.

0.5 Significance

The growing need for EE that weaves together Indigenous and Western Science is critical considering the current ecological and crisis and ongoing settler colonialism in educational spaces continuing to cause harm to Indigenous students. By addressing the interconnectedness of these knowledge systems, a more holistic understanding of environmental stewardship can be offered to students. With this dissertation, I aim to contribute to the growing body of work advocating for culturally responsive, relational, and adaptive approaches to EE. This research aims to develop, implement, and evaluate effective braided EE programs across contrasting curricular contexts. By reflecting on how these programs have emerged and evolved, a better understanding can be gained of how to foster meaningful learning experiences that promote environmental knowledge, attitudes, relationships with nature, and engagement with materials while also enhancing cultural responsiveness in educational spaces.

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Chapter 1

A checklist for developing school-based environmental education programs with community-engaged approaches that braid Indigenous and Western Science

1.0 Abstract

This paper presents a comprehensive checklist designed to guide the development of school-based environmental education (EE) programs that braid Indigenous and Western Sciences. Drawing from three years of community-engaged program development across six programs in two distinct curricular contexts, the checklist addresses key aspects of braided EE programs, including positionality, people, places, pedagogies, curriculum, and program planning. Supplementary questions, resources, and culturally responsive approaches to program development and evaluation are also discussed. This tool serves as one of many thoughtful, process-based guides for non-Indigenous individuals and others engaged in EE that incorporates Indigenous perspectives, offering valuable support for curriculum developers in the broader field of EE.

1.1 Introduction

Roots of our ongoing ecological crisis are thought to stem from fractured relationships between humans and the natural world (Hancock, 2019; Kimmerer, 2013). In response, there is growing interest in developing environmental education (EE) programs that equip young people with knowledge, skills, and relational understandings needed to transform relationships with the environment and develop capacity to engage in environmental stewardship (Salazar et al., 2022). Several teaching approaches, or pedagogies, exist to nurture human-nature relationships. For instance, Payne & Watchow (2008) and Yemini et al. (2023) describe how place-based learning can anchor learning in a physical place, fostering deeper connections to the natural world. Experiential learning that facilitates ecological restoration, such as ecorestoration service learning, enhances environmental knowledge and stewardship attitudes (Hansen & Sandberg, 2020; Knackmuhs et al., 2017). Additionally, incorporating relational values such as care and respect further deepen relationships to place, nature, and the land as outlined in a review by Dos Santos & Gould (2018). These pedagogies and practices are foundational to Indigenous environmental education. Tewa scholar Gregory Cajete (2010) highlighted that Indigenous perspectives are the *conceptual wellsprings* for modern EE, a notion echoed by Newbery (2012), McLean (2013), and more recently Hunter & Richmond (2022).

With this knowledge in mind, many educators are interested in braiding Indigenous and Western perspectives to provide a more comprehensive curriculum. Braided approaches leverage the strengths of both Indigenous *and* Western Science, offering complementary perspectives and processes for understanding and interacting with nature (Snively & Williams, 2016). Johnson et al. (2016), Shermata (2018), and Whyte et al. (2016) discuss how environmental stewardship and caretaking are viewed as conceptual bridges between Indigenous and Western Sciences, making curricula focused on these themes ideal candidates for braided science programs. Despite the

robust literature on braided education, including frameworks for Indigenous Science, core elements, and best practices for respectful incorporation content (e.g., Antoine et al., 2018; Datta, 2018; FNESC 2019; Mack et al., 2012; Snively & Williams, 2016; Sutherland & Henning, 2009; Sutherland & Swayze, 2011), there remains a critical need for practical tools that bridge the gap between theory and implementation in mainstream school settings, as mentioned by EE program practitioners Anderson et al. (2022a) and Drossman (2024) .

Several key gaps need to be addressed to facilitate the presence of braided EE programs in mainstream school settings. First, practical tools are needed to integrate braided EE into mainstream (formal) educational contexts, where the potential impact on youth is significant due to the large number of students. Given that integrating EE and braided learning across all grades and disciplines are educational priorities (Hunter & Richmond, 2022; Michie et al., 2018; Salazar et al., 2022), developing effective tools for educators is crucial for facilitating the seamless integration of these kinds of programs into schools. Second, EE needs more effective tools for monitoring and evaluation, especially for braided programs (Anderson et al., 2022b; Monroe et al., 2010; Shepherd & Graham, 2019), to support program enhancement, accountability, and securing funding opportunities. Third, non-Indigenous educators can face challenges in collaboratively developing Indigenous Science programs due to limited pre-existing relationships to community. A case study that delves into the process of relationship-building, positionality, and best practices for collaboration could provide valuable insights and practical guidance for educators seeking to develop Indigenous Science programs without established community relationships. Last, while broader frameworks provide valuable insights, detailed, grassroots perspectives are needed to complement guides generated from larger-scale approaches (e.g., via steering committees, workshops, surveys, interviews with regional educators; Augare et al.,

2017). I address these gaps by developing an evidence-based tool tailored for school-based braided EE programs, grounded in both existing literature and extensive hands-on experience. The objectives are to:

1. Develop and promote an evidence-based tool with supporting strategies, for creating and implementing new school-based braided EE programs in differing school contexts.

2. Provide guidance for educators—particularly those without strong pre-existing relationships with Indigenous educators and/or school communities—on how to develop EE programs with an Indigenous-Western Science component through community-engaged approaches.

3. Offer a detailed, grassroots-level perspective on program development drawn from a three-year experience developing six braided EE programs in two distinct curricular contexts within mainstream schooling.

The program development processes for each program component—positionality, people, places, pedagogies, planning program monitoring and evaluation—are described through my lens as program coordinator. I share key learning moments in a narrative fashion against the backdrop of best practices from the literature. I distilled main steps to program development into a checklist to facilitate uptake in different contexts (Figure 1), and conclude with reflections around the process of developing and using the checklist.

1.2 Approaches and Tools for Program Development

In this section I outline the program development processes by presenting the approaches that guided the development of Indigenous and Western Science EE programs in collaboration with community members. Key program approaches and their relevance to the program development process are described, including collaborative, culturally responsive, and developmental approaches**.** Additionally, in this section I introduces the use of checklists as a tool for program development, highlighting how checklists can help manage complexities involved with developing and implementing Indigenous-Western Science EE programs.

1.2.1 Main program approaches guiding program development

Given the important role of community members in developing these braided EE programs, program approaches that involve collaboration were used as guides. Collaborative program development is an approach in itself with different subsets, including "Indigenous culturally responsive" and "developmental." All three approaches involve the collaboration of program team members and learning with continuous feedback loops, as noted by program practitioners Cousins (2019), Hudson et al. (2017), and Quinn Patton (2013). Cousins (2019) describes the defining characteristic of collaborative (community-engaged) approaches to program research (e.g., design, development, implementation, evaluation) as *when non-evaluator program team members engage with the lead program coordinator in knowledge production related to program enhancement*. What sets culturally responsive approaches apart is the focus of Indigenous priorities and values at the heart of program activities (Bowman et al., 2020; Lafrance & Nichols, 2010). Developmental approaches are characterized by programs in emergent and complex settings, where program goals and processes may not be clearly defined at the outset but unfold over time as the programs and team members adapt to shifting contexts (Quinn Patton, 2013). These three program approaches are compatible (Cousins, 2019; Quinn Patton, 2013) and were used simultaneously in the program development described below.

Community-engaged (collaborative, developmental, Indigenous culturally responsive) approaches used in this study align well with braided EE programs because community-based epistemologies are central to Indigenous Science, and diverse approaches, techniques, and traditions are needed for teaching EE (Bang & Medin 2010; Hart & Nolan, 1999; Johnson et al., 2016; Monroe & Krasny, 2016; Swayze, 2009). Plus, the dynamic and somewhat chaotic nature of school environments presents an ever-shifting context which is well suited for developmental program approaches (Quinn Patton, 2011). Program practitioners engaged in community-based

work often use autoethnographic, narrative, reflective, and reflexive practices to engage thoroughly with research processes and share experiences (Hart, 2002; Koster et al., 2012, Windchief & Ryan, 2019). Thus, the insights and reflections shared throughout this chapter are grounded in my personal experiences and reflexive practice in my role as program coordinator and principal researcher, providing a nuanced understanding of the challenges and successes encountered. When describing my experiences, I use "I-statements" and reference the "programs developed here" to highlight what I have specifically learned through my personal experience as a community-engaged program practitioner.

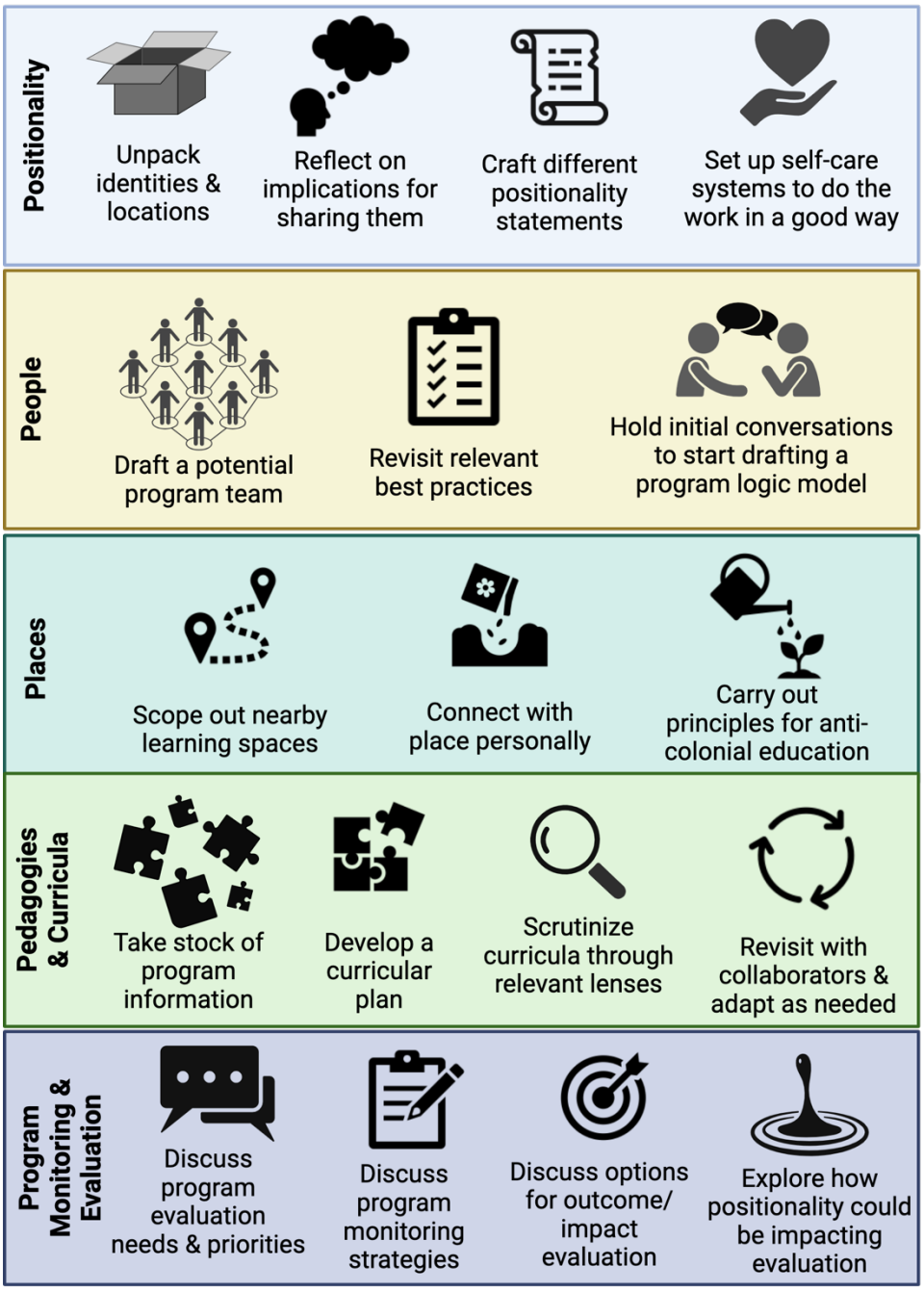
1.2.2 Checklists as program development tools

Given the multi-faceted nature of braided Indigenous-Western Science EE program development, program development processes must be able to navigate the complexity associated with dynamic school settings, diverse relationships, and different knowledge systems. A potential solution lies in using checklists as a program development tool. Checklists have been used in technical fields, such as aviation, medicine, and engineering (Gawande, 2010) and have been taken up in program research directing evaluation (Quinn Patton, 2013) and somewhat for developing EE curricula or research (e.g., Hart et al. 1999; Reid & Gough, 2000). Checklists streamline organization, provide direction, and can serve as a practical counterbalance to the heart- and mind-based work involved in developing braided EE programs with different community members. Checklists can be nested and mutually informative at various hierarchical levels, allowing sub-checklists to facilitate additional decision-making for each checklist item. Below I present a program development checklist compiled through reflecting on the past three-years of community-engaged program development activities (Figure 1.1). Each checklist item is discussed with relevant lessons learned in my role as program coordinator, supplemented with best practices from the literature and feedback from collaborators. The checklist is meant to be

used iteratively throughout the different stages of program development and returned to at implementation and evaluation stages. Atul Gawande's (2010) *Checklist Manifesto* inspired the development of the checklist idea and served as a guide.

Figure 1.1

A Checklist for Developing Braided Environmental Education Programs Using Community-engaged Approaches



1.3 Checklist Components

In the sections below I explore components of the checklist used in developing six braided Indigenous-Western Science environmental education programs at two distinct schools (Figure 3.1). The sections offer context for how I navigated key elements such as positionality, people, places, pedagogies and curricula, and program monitoring and evaluation, when engaging with community members.

1.3.1 Positionality

Kwaymullina (2016) describes positionality as the "pre-work" that must be done before working with community in program development or Indigenous contexts. Exploring intersectionality is considered an important part of self-decolonization (Acree & Chouinard, 2020; Wildcat et al., 2014). Exploring positionality (what our various social, cultural, etc. positions are) and intersectionality (how our various positions intersect to shape experience, privilege, and oppression) can be undertaken through unpacking various identities, reflecting on those identities and which are relevant to be positioned, preparing positionalities for the range of program collaborators, and following up with self-care related to keeping identities in balance.

Item 1.1 – **Unpack your various identities/locations**. As Lowan-Trudeau (2012) explains, introducing oneself to research participants or program team members can put people at ease and help the one's background, perspective, and various social, cultural, or other locations be better understood. Being able to describe ourselves to our program team members is also important for cultivating relational accountability, something Wilson (2008) describes as demonstrating values like respect, responsibility, and reciprocity in collaborative relationships (Box 1.1). I found that I needed to more deeply explore my own positions before embarking in work that would require me to position myself and answer questions around who I was in relation to the work at hand. To help map out my own locations, I found a comprehensive list of possible locations. For me, a

person with much outward presenting privilege contrasted with invisible or hidden identities typically considered lacking power (e.g., history of complex trauma, neurodivergent, gender nonconforming), I then explored which identities of mine were "fast" or easily visible and which were "slow," as in, invisible or needing more time to be seen. Mapping out these different intersections helped me to understand how each identity was being seen and heard in any particular context, the privileges or marginalization's associated with each, and the interactive effects of these identities that shaped my path and impacted where I am today and how I present myself in the spaces I am in. This inner/outer framework is not to dichotomize something inherently holistic, but rather to facilitate a productive self-study leading to deeper understanding.

Box 1.1

Principles of relational accountability from an Indigenous perspective

- **Reciprocity**, how the work will benefit their community (including the Land).
- **Relationship-building**, showing humility and integrity in personal interactions at informal and formal events.
- **Relevance**, having a research or program topic relevant to community (where the community might be engaged in developing the question, methods, and interpret data).
- **Respect**, honouring cultural protocols, non-judgmental listening, prioritizing partner values, employing Indigenous worldviews, being transparent.
- **Responsibility**, remain responsible and accountable to community.
- **Risk-taking**, acknowledge that risk is not equally shared, or topics may be inherently triggering.

Note. Drawn from Corntassel et al., (2020) and Wilson (2008).

Item 1.2 – Reflect on your various identities/locations and implications for sharing them. Once I gained a clearer understanding of my own identity, I began to grasp the implications of these identities and how I needed or wanted to articulate them. Navigating how to share my

identities in any particular space has been and continues to be a challenging process. Some aspects of myself, such as being a beneficiary of settler colonialism in line with my position as a non-Indigenous person engaging with Indigenous education and culturally responsive program work, I must reconcile with and be comfortable sharing, as encouraged by white EE educators and program evaluators Korteweg & Russell (2012) and McKegg (2019), respectively. Other aspects—primarily the "slow" or invisible parts of my identity—have proven more challenging. Clarifying what I need to share, want to share—and why—remains a dynamic journey. Some exercises that help me navigate different spaces include: reflecting on how the gifts of each identity could benefit the space or could unintentionally cause harm; discerning which aspects of my invisible identity are important for relational accountability and how I choose to articulate those; understanding when sharing aspects of identities would be appropriate and support the priorities of the space (versus being used as conscious or unconscious tactic to detract from positions of privilege); and establishing boundaries of what should be shared, could be shared, or might never be shared about myself.

Based on what I have learned and experienced, there can be personal and professional merit in stepping outside of one's comfort zone with mindfulness and good intention. For instance, in my role as facilitating neurodiverse and trauma-recovery support groups, some view self-location as opportunities for micro-activism, setting a tone of inclusion and acceptance, or reclaiming notoriously omitted identities. Some neurodiverse researchers feel strongly that our identities impact the research itself and must be named, or that concealing aspects of a stigmatized identity can exacerbate self-stigma in some cases (Gerlach et al., 2021; Mayes, 2020). Through trial-and-error with positioning over the last several years, I have found that if I

perceive my identities to impact the working relationship, it is worthwhile to position as authentically as possible at the outset.

Item 1.3 – **Preparing different positionality pitches permits flexibility in catering to different audiences and program partners**. Having explored my identities and boundaries, I was able to prepare to present myself to different partners, crowds, and spaces with varying needs. I have found it best to have a few different positionality pitches available to navigate the diverse contexts encountered in community-engaged program development work. Learning how to calibrate my required self-location to a particular context is a skill I continue to refine over time with patience, compassion, and some amount of courage. Kapyrka and Dockstator (2012) outline how creating a positionality statement through storytelling as pedagogy—by weaving personal narratives with self-location—can serve as a welcome counterbalance to the traditional approach used in the colonial process of ethics approval, which I have employed in my own research relationships and was appreciated by an Indigenous colleague. In line with what scholars suggest, I generally prepare to address the following: who I am, where I am from (and my grandparents); why I am here; why I care; what my current relationships to community are; knowledge of the community; expectations for doing this work; how community members could be involved; what I am asking of the community; and how my visit will benefit the community (Bowman 2020; Corntassel, 2020; Koster et al., 2014; Kwaymullina, 2016; Madden, 2014; McKegg, 2019; Root, 2010; Wilson, 2008). These questions are particularly important for non-Indigenous educators engaged with Indigenous education and/or program work (Korteweg & Russel, 2012; McKegg, 2019).

Other practices that have helped me navigate self-location include: understanding that I do not need to fully position myself at any one-time, discerning disclosure versus sharing,

reflecting on which identities of myself matter to each community partner, revising self-locations as new information about myself becomes available, preparing iterations of different positionality pitches for contextual agility, and reflecting on the implications of sharing certain positions. When preparing for positionality, I have found it helpful to consider duration (short, medium, long), audience (students, educators, peers, academics, community members, Elders/knowledge keepers/mentors), and content (family background, passions, experience, defining characteristics). Although having a few practiced scripts might be superfluous, this practical exercise may benefit fellow neurodivergents where being in new environments with new people can be overstimulating. Expecting the unexpected (e.g., people you may not know could be at or within earshot of a private meeting) and adapting to the flow of each circle/meeting are principles that have been added to my positionality practice.

Item 1.4 – **Set up self-care systems to do the work in a good way**. Even before meeting with my community partners, understanding and learning to articulate my own positionality was challenging. It became important for me to pay attention to identities that felt triggered or needed extra care by being in particular spaces, explore what I needed to be fully present for this work, identify self-care practices necessary to sustain me, and remain curious about the challenges that kept arising or getting in the way while doing this work. Finding a "community of recovery" to complement my community of practice was necessary to nurture my ongoing recoveries and create space for less public-facing identities that were critical for shaping my identity.

1.3.2 People

Relationships are at the heart of community-engaged program development. Below, I explore three key checklist items in the "people" component: drafting a program team, familiarizing myself and following best practices for community-engagement within an Indigenous context, and holding multi-phase conversations.

Item 2.1 – **Draft program team & build relationships**. Swayze (2009) emphasizes the importance of collaboration across education sectors in developing braided EE programs with community-engaged approaches. A good initial step is to ask, "*Who are the people that could or should be involved in this work?*" The list of people will likely be main collaborators or consultants that you would like to either inform the program or keep informed of program processes. A next step was assessing opportunities for community connections, whether they be external educational organizations or community member involvement. As a researcher new to the area with no prior relationships to the educational community, relationships were developed initially through my supervisor and networks expanded through word of mouth, encouragement of Indigenous educators at schools, and through the assistance of a community-campus hub. For my own experience in securing host classrooms for the programs, I approached one teacher and was approached by one teacher at a different school. Familiarizing myself with cultural or community protocols around initial meetings and collaborations, such as bringing gifts or food to share, is something I overlooked during this step.

While three teachers served as main program partners, the broader network of community-engaged program team members extended to students, other teachers at the school, educators at the school district level, educational assistants, nature-oriented community organizations, community members, and curriculum developers. Cousins (2019) and Dion et al. (2020) describe how program partners can range from consultants, collaborators, or co-creators, and that mechanisms of community-engagement will depend on the program partner, capacity, and stakes in the project. They also mention how relationships may evolve over time to better support the program. I found this to be true in the Indigenous-Western Science EE programs described here, where some partners were key for connecting people and places in earlier phases

of the program but became less involved in mid-to-later phases as those relationships became self-sustaining.

Item 2.2 – **Revisit relevant best practices to nurture relationship-building.** This section includes several sub-checklists outlining best practices around collaborative program development in Indigenous contexts. A key tenet of collaboration is ensuring reciprocal benefits—that the research is going to benefit the community with whom you are working (Wilson, 2008). Although finding a common goal can be challenging, having a shared vision and common needs are of utmost importance to ensure reciprocity and value to your collaborators, to maintain respectful and ethical partnerships, and is a core feature of collaborative program processes as mentioned by Cousins (2019), Dion et al. (2020) and Fetterman et al. (2018). Before meeting with program partners, it was important for me to ensure that the work upheld aspects of relational accountability and to was prepared to articulate these to my various collaborators (Box 1.1). As highlighted by LaVeaux & Christopher (2009) and Shepherd & Graham (2020), upholding relational accountability is often deemed more important than the research question or statistical validity. Being familiar with principles of collaborative program development and principles for working within an Indigenous context were also helpful for me to keep in mind (Boxes 1.2 and 1.3). Overall, I found that being flexible, prioritizing community need over research questions, being open to making mistakes, being open to change, focusing on showing up, and demonstrating patience and persistence were helpful principles to apply throughout this iterative relationship-building phase.

Box 1.2

Principles and Practices for Collaborative Program Development

- Identify the situation—stakeholders; logic model; strengths, weaknesses, opportunities, threats (SWOT) analysis, evaluation scope and activities
- Develop a shared understanding of the program (e.g., inputs, people, settings, activities, goals, outcomes, impacts, assumptions)
- Clarify motivation for collaboration (who, their values) and their expectations
- Establish a collective commitment
- Foster meaningful relationships that are respectful, trustful, transparent, interactive, reliable, culturally competent, sincere.
- Promote appropriate participatory processes, monitoring and responding to resource (time and money) availability
- Monitor evaluation processes with effective processes
- Practice open communication (listening, feedback, clarity)
- Promote evaluative thinking (inquiry-based, focused on learning, belief in the power of evaluation)
- Discuss some method of formative evaluation for improvement
- Take a developmental focus with knowledge exchange
- Focus on capacity building
- Demonstrate empathy, sensitivity, understanding, and thoughtfulness towards emotions of others.
- Collaboration should promote empowerment, self-efficacy; delegating authority; and removing obstacles.
- A feasible and constructive blend of forces.
- Development, training, mentoring, for learning and improvement.
- Ensure program team members have or can develop proper qualifications, knowledge and skills
- Follow professional standards and guidelines for data quality and evaluation design
- Foster social support, productive networks, belonging
- Set up accountability systems to achieve outcomes/impact
- Follow through to realize use with practical outcomes

Note. Informed by Cousins et al., (2019) and Fetterman et al., (2018).

Box 1.3

Principles for Conducting Community-engaged Research within an Indigenous Context

- Recognizes the community as a unit of identity.
- Builds on strengths and resources of the community.
- Facilitates collaborative partnerships in all phases of the work.
- Integrates knowledge and action for mutual benefit of all partners.
- Promotes a co-learning and empowering process that attends to social inequalities.
- Involves a cyclical and iterative process.
- Addresses wellness from both positive and ecological perspectives.
- Disseminates findings and knowledge gained to all partners.

Note. Based off of findings from LaVeaux & Christopher (2009).

Item 2.3 – **Hold initial conversations to ascertain program information to build or add to a program logic model.** Over several years, relationships were nurtured through conversations with collaborators in formal and informal settings, school visits and observation periods, and attending community events. Regardless of the setting, meetings tended to be loosely goal-oriented, prioritizing either getting to know program partner values, goals, priorities and capacities, or brainstorming about curriculum development and implementation. Understanding program partner priorities, strengths, needs, values, capacities, monitoring and evaluation needs, and general preferences was important for shaping program development. Such conversations were critical early on in program development. As mentioned by Rodríguez-Campos & Rincones-Gómez (2013), program elements can shift over time, thus it was important for me to revisit main program elements with collaborators. I also respected and followed-up on any suggestions from community partners by making a list of actionable items or writing/reflecting after each meeting. Chen (2014) notes that diligent note taking is generally good habit for program practitioners to create program documents and record activities.

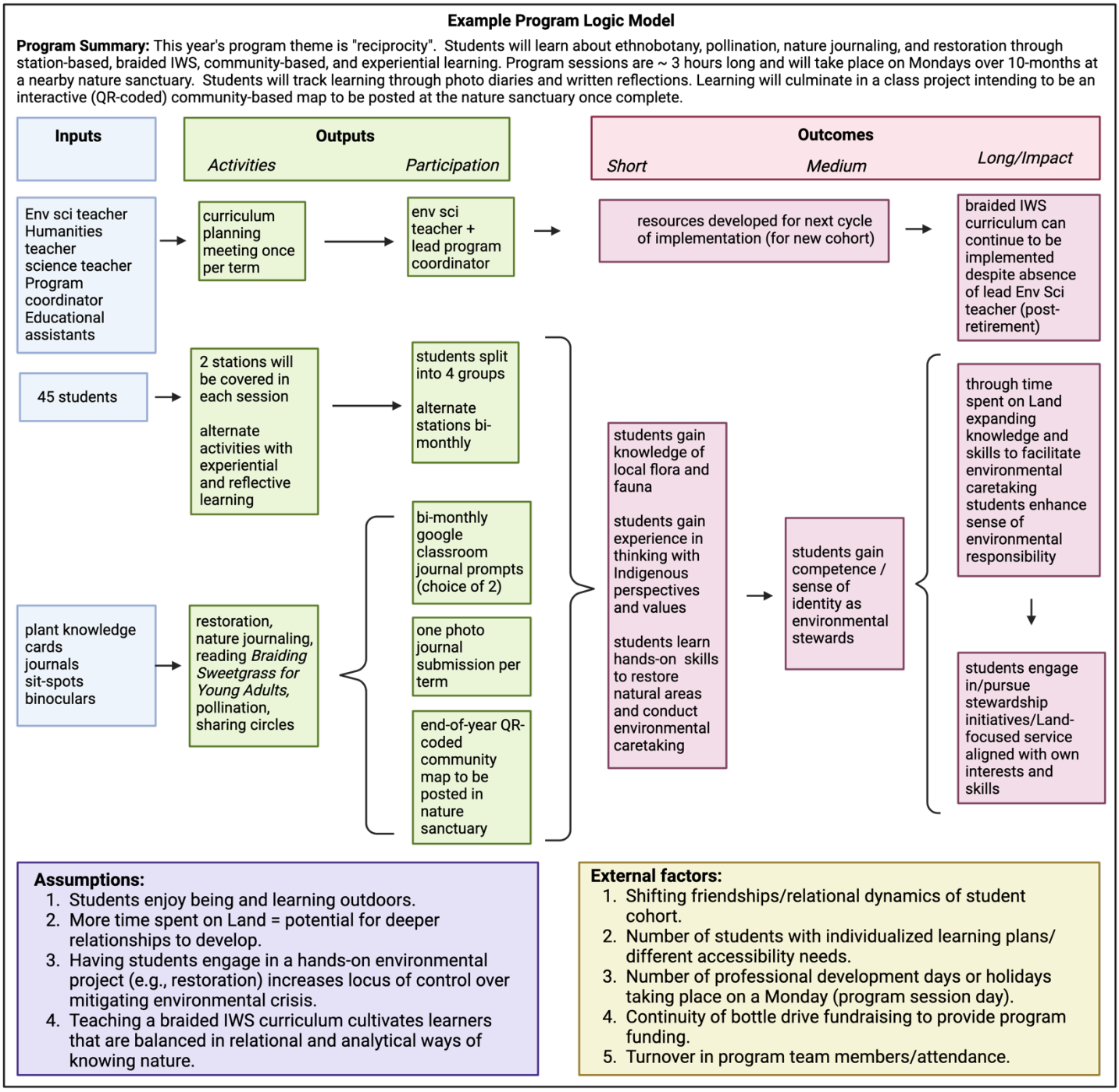
These initial conversations can reveal information that can be added to a program logic model: a diagram of program elements that a depicts what the program does, for whom, and why. Such a diagram often contains inputs (people, places, activities), outputs, outcomes, assumptions, and external factors (Porteous et al., 1997). However, as noted by Quinn Patton (2013) many program elements may be uncertain for emerging or community-developed programs. Thus, continuing to add to a logic model over the course of multi-phase conversations helps to lay solid foundations for future program development and implementation.

An example of a program logic model for one of the six programs I helped developed in this study is shown in Figure 2. Co-constructing these program elements was an iterative process

based on feedback and input from program partners through multi-phase conversations. Eventually, program goals solidified as enhancing multiple dimensions of the student learning with respect to environmental stewardship (i.e., enhance environmental attitudes and knowledge, relationships with nature, engagement with material) using braided, experiential, and service-based learning approaches. During these initial conversations it was worthwhile to explore how these programs could be of service to the community given the resources and opportunities available, such as restoration and removing invasive species, planting pollinator gardens, composting, maintaining ethnobotanical or other gardens, or other services relevant to the school or community context.

Figure 1.2

Example Logic Model



Note. Depicts program elements gathered through multi-phase conversations with program collaborators in the Mature-context during program development.

1.3.3 Places

Often referred to as "First Teacher," land is central to Indigenous epistemologies including those practiced in EE. Land is alive, storied, and carries the ancestors of the First Peoples, and provides ideas for activities and knowledge that can be shared with students. (Simpson, 2014; Tuck et al., 2014). Land and place are central to Indigenous EE, as ancestors, dreams, stories, knowledge, kinships, and relatives are all part of the land, providing ideas for activities and knowledge that can be shared with students (Simpson, 2002; Swayze, 2009). The checklist items cover some logistical considerations and Indigenous Science protocols for conducting outdoor learning within braided or anti-colonial education[1].

Item 3.1 – **Scope out nearby learning spaces**. Typically, these local green spaces should be within walking distance of the school (5-15 minutes depending on total class time) and contain enough local plants and animals for experiential activities. If possible, coordinate with land managers to conduct restoration on-site. Although these characteristics contribute to a high-quality learning space, a collaborator once remarked: "When there's a will, there's a way." Even schoolgrounds can serve as valuable venues for outdoor learning.

Item 3.2 – **Connect with place**. Indigenous peoples are part of the land and vice versa; getting to know one requires getting to know the other. Maintaining a respectful relationship with the land was an integral part of my personal practice through all program phases. Establishing a relationship with place involves spending time on the land. I view these initial connections as sowing seeds of intention, gratitude, and respect to create solid foundations for future group learning and teaching. Some practices that I have learned from local Coast Salish scholars, Knowledge Keepers, and Elders include introducing myself (who I am, where I come from, and

[1] Anti-colonial education refers to educational practices that actively challenge and dismantle colonial ideologies and structures. It seeks to empower Indigenous peoples, knowledge systems, and cultures while critiquing ongoing settler colonialism (Battiste, 2013).

what do I plan to do here), bringing a gift, walking with humility and respect, continuing to reflect on my responsibility to the place I am in (Claxton & Rodríguez de France, 2019; Mowatt et al., 2020). If unsure of acceptable practices, consider asking a member of the community or collaborator for local protocol of the respective culture or First Nation.

Item 3.3 – **Carry out principles for anti-colonial environmental education**. Nurturing my intentions as an educator (or, the intentions of the teaching team I was a part of in some instances) involves following principles for an anti-colonial environmental education (i.e., education that resists colonial processes) and upholding Indigenous pedagogy as a non-Indigenous person in respectful ways. Because the land is alive with ancestors, protocols across many Indigenous cultures exist around treating the land as a being and upholding good relations with respect, reciprocity, and responsibility (Bang et al., 2018). Some practices that I have learned from local Coast Salish scholars, Knowledge Keepers, and Elders include demonstrating respect for plant and animal ancestors, the land, and one another; learning from and with the land and community; engaging in observation and experiential learning; incorporating both Indigenous and non-Indigenous perspectives into the curriculum; grounding lessons with intentional openings; using storytelling (e.g., sharing positionality and introducing oneself to the land and each other); asking permission before working/being there; and fostering learning through sharing circles (Claxton & Rodríguez de France, 2019; Mowatt et al., 2020). Additional pan-Indigenous Science protocols involve recognizing the land as an active participant in the learning journey, extending relational accountability to the land, and offering gratitude (Cajete, 2000; Johnson et al. 2016; Kimmerer, 2017; Pyke et al., 2018; Reo, 2019; Whyte et al., 2016).

Educators can avoid perpetuating colonial education through: learning about and acknowledging the specific traditional territories (e.g., people, history, language) in which they

are on; that they are on traditional territories and land with long difficult histories; asking permission from the land itself and from the local nations; traveling with humility rather than entitlement; embracing difficult knowledge, learning, and teachings; learning on the land with Indigenous peoples/community members when possible, and centering Indigenous peoples/ancestors of that place (Datta, 2018; Joseph, 2020; Mowatt et al., 2020; Newbery, 2012). Through ongoing community engagement over the past few years attending classes, workshops, land-based learning events or informal gatherings, I have learned about local protocols from local Coast Salish scholars, educators, Knowledge Keepers, Elders, and community members and have woven them into lessons with permission.

1.3.4 Pedagogies & curricula

After several conversations, relationship building, and spending time in community, I developed a solid idea of what kinds of pedagogies, activities, and content the EE programs could include. A few process-based and content-based sub-checklists are listed below. Generally, I gathered available information and needs from program partners, drafted a curricular outline, vetted the outline with relevant lenses, and adapted and revisited curricular with collaborators as needed.

Item 4.1 –**Take stock of what information you have gathered**. Taking stock of what was shared during the initial conversations was an important first step in structuring the curricular plan. Usually, input included: pedagogic priorities (topics, activities, tactics), assessment techniques, program duration and frequency, physical resources available, teaching capacities, and preferences mentioned by the range of collaborators (students, educators, community members). Noting prior knowledge and skills of different program team members also helped shape the program curricula. After a few program cycles, I began to gather preferences of the participating students during the pre-program surveys for topics and learning approaches they enjoyed most or wanted to explore.

Item 4.2 – Develop a curricular plan. Through my experience in community-engaged program development, I often felt that the process was somewhat like building a mosaic. Characteristics of each mosaic piece were specific to the program partner inputs yet coordinating the "pieces" to fit together within the "frame" of the program to tell a story was ultimately done by the lead program coordinator. After taking stock of the program's "mosaic pieces", one can construct the larger program picture. This step of developing a curricular plan typically involved laying out detailed lesson plans to achieve the overall program goals. The curriculum must be taught but somewhat resisted (Swayze, 2009). Finding creative ways to teach aspects of the curriculum that honour the level of integration available for the school context was important in mapping out the curricular plan.

As discussed by Simpson (2002), Indigenous Science tends to be process-based while Western Science is often concerned with content. Over time, I found that Indigenous and Western Science could be woven more comprehensively by focusing both on process *and* content of lessons, and each lesson looked a little different. Examples of how Indigenous and Western Science elements were braided in a lesson include: opening the lesson in circle with a land acknowledgment given by a student or teacher, stating a general intention or reflection point around that particular topic (e.g., gifts received and how we can be good relatives), hands-on or experiential exploration of a topic through either practicing Western Science procedures of plant, soil, animal or water analysis, learning and using Indigenous names for plants, animals, water when possible, and having multi-generational teaching and learning or different community members present.

Item 4.3 – **Scrutinize the curricular outline through relevant lenses**. Vetting the curricular plan was an iterative step to ensure that the multiple collaborator and program needs were being

met. I began by asking: "*What is this particular program trying to uphold*?" and made sub-checklists based on those answers. In the programs described here, the goals were to braid Indigenous and Western Science, develop them in collaboration with the community, enhance participants' environmental stewardship across multiple dimensions, and ensure inclusivity for a diverse range of participants. Given those principles, I created sub-checklists to help me vet the curricula with those particular lenses (Box 1.4). In discussions with collaborators, various needs and inputs were recorded and compiled into a checklist (Box 1.4A), whereas the literature served as a major source of information for specifics on braided Indigenous-Western Science or Indigenous pedagogy (Box 1.4B) and theory around cultivating environmental caretaking (Box 1.4D). My personal experiences as an educator and learning how certain activities engaged or disengaged certain students helped me curate a checklist on inclusivity (Box 1.4C). A final step of examining curricula was to explore how my own intersectionality was reflected in the curriculum (or lack of curriculum). I found this to be useful for detecting how certain characteristics or sensitivities of my neurodiversities were impacting the curriculum. Bringing this to light allowed me to further explore whether these things were enhancing the teaching/learning, or hindering it, and enabled me to make informed decisions.

Box 1.4

Sub-checklists to Refine Curricula

A) Collaborator priorities

- Is there a way they can learn by doing stuff?
- Is this engaging all their senses?
- Is this repetitive enough, in terms of content?
- Is it repetitive, in terms of visits to nature to create a culture?
- Is there time to just be?
- Are you going deep enough with content?
- Is learning real and hands-on?
- Is there freedom to engage with the Land?
- Is there artwork?
- Is there choice?
- Can they see they are making a difference?
- Is there a way for them to make special relationships to place? (e.g., a certain tree or animal)
- Are Indigenous peoples involved with learning or instruction?
- Are there heart-felt Land acknowledgments? Continual reflections on responsibility to Place?
- Is there an opportunity to steward or take care of something?
- Have sufficient curricular connections been made in terms of competencies, content, and big ideas?

B) Components of braided Indigenous-Western Science education

- Acknowledging the harms of colonial violence and analyses settler colonialism.
- Land is central and shapes relationships; is an active partner in healing.
- Learning is a collaborative, co-learning journey.
- Uses story and self-location.
- Leans on the strengths of Indigenous Science, the strengths of Western Science
- View science in an inclusive way
- Does things in a creative way (versus just talking)
- Examines values, actions, and knowledges
- Uses visuals
- Weaves between worldviews
- Gains input from educational and Indigenous communities
- Respect, reciprocity, relationships, and responsibility as guides of etiquette and interaction
- Teaches relevant Western Science perspectives, terms, skills, or practices so learners can engage with Western scientists
- Teaches WS as just one perspective and evaluates WS critically (e.g., negative impacts on Indigenous peoples past and present).
- Use or reference to Indigenous instructors and scientists as much as possible
- Leave space for student responses to difficult learning
- Process-based
- Critically explores contrasting IS/WS worldviews
- Holistic teaching—knowledge embedded in cultural context
- Teaches responsibility—knowledge is attached to responsible action
- Does not sever spirituality from Indigenous knowledge

C) Environmental caretaking

- Opportunities to conduct caretaking (e.g., respectful outdoor learning, stewarding plants or animals, cleaning up or restoring the land, noticing gifts, offering gratitude)
- Opportunities to reflect on caretaking.

D) Inclusivity

- Pictures or infographics accompany written text
- Hands-on or experiential learning and doing when possible
- Support for learners whose first language is not English
- Multiple ways of communicating
- Scalable activities
  - In content and detail
  - In numbers (independent or group work)
  -
- Alternating modes of learning (experiential, reflective, etc.)

Note. A series of sub-checklists used to vet curricular outlines based on collaborator needs and specific program goals

Item 4.4 – **Revisit with collaborators and adapt as needed**. During this curricular planning stage, collaborators mentioned that we found success by having a plan to work from while maintaining flexibility to adapt that plan in response to the rhythm of student interest, cycles of the natural world, and emerging opportunities. Revisiting and adapting the curricular plan as needed or at distinct timepoints through the school year or program lifespan was essential.

1.3.5 Program monitoring & evaluation

Discussing program evaluation needs and mapping out monitoring or outcome evaluation plans are critical during the program development phase.

Item 5.1 – **Discuss program evaluation needs and priorities**. The capacities and priorities of program partners shared in earlier conversations helped guide which evaluation(s) were a good fit for these programs being developed. If capacities and priorities have not been previously

discussed, it is prudent to outline monitoring needs and priorities, especially since monitoring and evaluation can serve both as program refinement tools and student assessment techniques (Monroe et al., 2010). There are different types of program evaluation (e.g., evaluating program processes *or* outcomes) and various approaches to conducting each type. Regardless of the type or approach, some sort of program evaluation should be conducted to gather general information about program processes and implementation, or insight on program effectiveness in achieving program goals.

Development of programs described here was guided by principles of collaborative, developmental, and culturally responsive practices; these principles can be extended to evaluation. Key practices involved in collaborative evaluation include having formal and informal conversations, securing local input on design and implementation, being attentive, soliciting feedback from program community partners across all program phases, honouring partner values, keen observation with the goal of refinement, deep listening, upholding relational accountability, being flexible, and using reflection and reflexivity about one's own practice to be a better colleague, evaluator, instructor, or ally (Boyce & Chouinard, 2017; Cousins, 2019; Fetterman et al., 2018). Additional techniques involved in culturally responsive Indigenous evaluation are listed in Box 1.5.

Box 1.5

Evaluation Techniques Aligned with Culturally Responsive Indigenous Evaluation

- Using talking circles as an evaluation tool
- Using mixed methods
- Triangulating qualitative and quantitative evidence sources
- Having an advisory board if possible
- Upholding relational accountability
- Continuously weaving findings for program refinement into future development
- Soliciting local input on design and implementation
- Having clear and measurable objectives
- Engaging in an iterative and reflexive process
- Continuously refining programs with an evidence-based feedback loop
- Including Indigenous program partners in all phases of research
- Listening and following through on suggestions and needs
- Honouring cultural norms
- Being reflexive and reflective about one's own practice, privilege, biases, assumptions to become a better ally in evaluation

Note. Informed by Bowman (2020); Boyce & Chouinard (2017); Brown & DiLallo (2020); and McKegg (2019).

Item 5.2 – **Co-create a program monitoring plan for process evaluation**. Process evaluation can help detect implementation strengths and challenges on a day-to-day basis. Especially for programs that are emergent or novel, monitoring program processes with process evaluation can help determine whether the number of students being reached, coverage of activities and topics, program setting, and duration and frequency of program sessions, are as desired. Understanding implementation dynamics is valuable for refining activities and processes to better achieve program goals, particularly for newly developed programs that have not yet widely implemented. Given the logistical challenges in implementing land-based or outdoor braided EE, as mentioned by Fleischner et al., 2017, having a finer-grained picture around program processes could elucidate program implementation and illuminate pathways to overcome logistical barriers often seen in mainstream settings. Moreover, gathering data more frequently through process evaluation can mitigate issues with patchy attendance that could skew pre-post program data associated with outcome evaluation.

In these programs, process evaluation was undertaken with semi-regular reflections, observations, and conversations with teachers and students. Aligning process evaluation with

formative assessment and embedding these techniques into curricula, such as reflective journal entries, served both my research and the goal of the teachers. Looking for behavioural indicators—something that can be seen, heard, or read during program implementation to indicate progression towards intended outcomes—also provided insightful information. Being opportunistic with casual conversation before, during, and after lessons with program participants and team members to gain information about program processes (e.g., what could be changed, what is enjoyable, what is challenging) proved to be a flexible yet effective process evaluation technique.

Item 5.3 – Discuss options for measuring impact on participants with outcome evaluation. Outcome evaluation provides insight to whether a program has met its goals. In the programs described here, the goals are to enhance environmental knowledge and attitudes, engagement with material, and relationships with nature. Evaluation practices differ depending on type of stakeholder. For student participants, multiple forms of outcome evaluation were conducted so data could be triangulated to build a more comprehensive picture of program impacts. We typically held a closing circle that posed open-ended questions or had a "seed-stick-stone" format for something students wanted to learn more about, something that would 'stick' with them, and something that was 'hard' or challenging, respectively. I also administered pre-and-post program Likert-style surveys, and when possible, conducted post-program focus-groups. With educators, I typically had one comprehensive closing conversation with each main collaborator, asking questions around program development, implementation, outcomes, and then some general questions around their own teaching philosophy or best practices. Being open to going with the flow of a program's growth is a hallmark of developmental evaluation (Quinn

Patton, 2013). Adapting and being flexible in evaluation proved useful in school-based settings, where different students, topics, and times of year presented varying evaluation contexts.

Item 5.4 – **Explore how positionality could be impacting evaluation.** Last, it is important to explore how positions of privilege could be impacting evaluation, especially for White, non-Indigenous educators engaged in programs that have an Indigenous component (McKegg, 2019). As outlined by Indigenous program practitioners Bowman (2020), Lafrance & Nichols (2010), and Swayze (2009), having a strengths-based lens, being objective, focusing on growth instead of progress, and considering alternate measures of program success are important considerations for evaluating Indigenous-focused programs in addition to keeping cultural values at the center of evaluation.

1.4 Reflections

This checklist emerged from a deep reflection of experiences, writing, dreams, paying attention, collaboration, and conversations on what I could have changed or what I wish I had known during the process of developing the braided EE programs using community-engaged approaches. Guided by Atul Gawande's (2010) insights on checklist failures—due to ignorance (lack of knowledge) and ineptitude (failure to apply knowledge properly)—I assessed moments where my understanding was incomplete or where better application of knowledge could have enhanced the process. These reflections not only informed the refinement of the checklist, but also emphasized its role as a dynamic tool intended to address both gaps in knowledge and practical implementation challenges. While checklists can be valuable tools for guiding program development, they should not be seen as rigid rules or regulations. Some potential drawbacks include the risk of oversimplifying complex processes, limiting creativity, or encouraging a "check-the-box" mentality where deeper engagement with context-specific nuances is overlooked. Checklists should be viewed as flexible frameworks that provide guidance rather

than strict prescriptions, leaving room for critical thinking, adaptability, and the unique needs of each educational context.

A recurring challenge throughout the program development process was determining whether I was doing "enough"—enough for the community, the program partners, the program participants, program values, and for the land itself. Another challenge I encountered during program development was discerning which role was required of me across different contexts and balancing logistical concerns with maintaining a present and receptive heart and mind. A key takeaway from my experience developing programs with community-engaged approaches is the importance of being process-oriented rather than goal-oriented. A First People's Principle of Learning—patience and time—was helpful for me to keep in mind when building relationships with people and place.

Learning to listen to the land, myself, and other people was another important learning experience in my role as a program coordinator. For instance, a mentor advised me to prioritize attending community events, which provided significant learning experiences that influenced the programming and curricular materials I developed with other teachers. Another valuable piece of advice from a mentor was to simply "show up," which eased my concerns about social capacity and engaging in unstructured social settings. Acting on suggestions from community partners helped demonstrate relational accountability and allowed me to evaluate my contributions.

Recognizing the land as an active collaborator in program development became increasingly important to me, a lesson that deepened after several programming cycles and was catalyzed by a significant dream. In the dream, I was facilitating a scavenger hunt but felt unprepared because the setup was inadequate. Reflecting upon waking, I realized that the deeper message wasn't about the need for more preparation, but rather, a call to embrace the

unpredictability of nature and trust in the land's guidance. By attuning myself to the rhythms and gifts of nature, I learned to collaborate more effectively with the environment—seizing teachable moments and adapting lessons in real-time to align with the natural world. Other dreams have included suggestions for curricular materials, or names of collaborators as a nudge to reconnect. Finding a balance between external influences (collaborators, land/place/nature, literature) and internal guidance (reflection, reflexivity, dreams) enriched both my program development and personal learning journey.

1.5 Conclusion

This paper presented a checklist as a tool for developing braided Indigenous-Western Science EE programs using community-engaged approaches with the intention of integrating these programs into mainstream schooling. Drawing from collaborative, developmental, and culturally responsive program approaches, the checklist was generated through narrative reflections of myself as lead program coordinator, reflecting on lessons learned over the past three-years of community-engaged program development and supplemented by best practices from the literature. As Indigenous-responsive education is needed at every level of schooling (Michie, 2018) and dismantling racist educational structures is everyone's responsibility (St. Denis, 2010), this checklist aims to facilitate the integration of braided models of learning and teaching across various contexts. Given the environmental stewardship focus, these programs can help strengthen student-nature relationships, although the specific intent of the program can be easily adapted. This checklist can serve as a valuable starting point for program practitioners interested in engaging with braided EE programs or as a development rubric for similar existing programs.

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Chapter 2

Process evaluations of six school-based environmental education programs that braid Indigenous and Western Science in contrasting curricular contexts

2.0 Abstract

This paper describes program implementation of six school-based environmental education programs that braid Indigenous and Western Science to enhance multiple dimensions of student learning. Programs were implemented for Grade 9 and 10 students at schools that differ in curricular structure, level of environmental education integration, inclusion of community-engaged learning, and experience braiding Indigenous and Western Science. Process evaluations were conducted with developmental approaches to refine program implementation given program goals of enhancing engagement with material, environmental knowledge and attitudes, and relationship with nature in learners through braided, experiential and community-engaged approaches to learning. Revealed through triangulation of student and collaborator feedback and practitioner observations, process evaluation findings are discussed in terms of trends in implementation changes over time and implementation strengths and challenges across programs. By depicting program evolutions through process evaluations with a developmental focus, these findings present potential implementation models for braided environmental education programs in different curricular contexts that seek to serve as grassroots approaches to enhancing multiple dimensions of student learning related to environmental stewardship.

2.1 Introduction

Increasing the presence of environmental education (EE) in school-based curricula is considered a grassroots approach to addressing current environmental challenges (Salazar et al., 2022). Environmental education seeks to enhance students' environmental attitudes, knowledge, awareness, behaviours, relationships, and skills to develop capacity for engaging in environmental stewardship and taking action toward enhancing ecological and social wellness (Clark et al., 2020; Monroe & Krasny, 2016). Although various approaches to implementing EE exist, a common approach emphasized by Pedretti (2014) is through science education, where "the environment" serves as a central organizing theme for curricula.

The reach of science within EE can be extended through braiding Indigenous Science perspectives and pedagogies with the Western Science curriculum (Charles & Cajete, 2020; Hunter & Richmond, 2022; Kimmerer, 2002; Pedretti, 2014; Sutherland & Swayze, 2012). As notions such as caretaking and responsibility are embedded into Indigenous Science practices, braided science programs are an ideal way to instil ethical environmental stewardship attitudes in learners while teaching skills and knowledge associated with Western Science (Johnson et al., 2016; Whyte et al 2016). At the same time, braided science is considered an anticolonial approach to science education that works to dismantle oppressive structures that have typically excluded Indigenous perspectives in science (Held, 2019; Kimmerer, 2012). Weaving Indigenous and Western Science (IWS) perspectives is beneficial to both Indigenous and non-Indigenous learners through balancing relational and analytical understandings of nature that prepare students for engaging in broader discussions around environmental problem solving and decision making (Kimmerer, 2012; Simpson, 2002).

Although non-Western perspectives and epistemologies, such as Indigenous worldviews, can enrich environmental education and disrupt colonial processes (Hunter & Richmond, 2022,

Tupper & Mitchell, 2022) settler or non-Indigenous educators experience challenges to implementing braided programming such as: fear of appropriating Indigenous knowledge and culture, offending others, and reproducing stereotypes; lack of sufficient relationships with Indigenous educators or community members; presenting the cultural and spiritual context inherent to Indigenous worldviews; engaging with difficult knowledges related to colonial violence; and, implementing process-based, living, and land-based knowledges within content-focused classroom-based curricula conventional to colonial educational systems (Bartlett et al., 2012; Fast & Drouin-Gagné, 2019; Kimmerer, 2012; Tupper & Mitchell, 2022). Implementing braided programming is further complicated by how Indigenous voices are expressed across and within schools (e.g., teachers, administrators, community relationships).

What's more, as relationship to land is central to Indigenous pedagogy and critical for cultivating deeper caretaking relationships with land (Diver et al., 2019, Simpson, 2014), upholding braided learning requires programming to be situated outside the classroom, at least partly, where students can connect to land, themselves, and the community (Nesterova et al., 2020). Braided learning also tends to be experiential and involve learning with, and being of service to, community (e.g., service-learning, community-engaged learning) (Bang & Medin, 2010; Snively & Williams, 2016). Despite the potential benefits of outdoor, experiential and community-engaged learning delivered through a braided curriculum, several barriers—such as timing, mandated curricula, large class sizes, funding, limited resources, fear, and lack of confidence or experience—often hinder its uptake in school settings (Bell, 2001; Fleishner et al., 2017; Harris, 2023).

Process evaluation is essential for navigating the challenges of implementing braided EE programs and ensuring they meet their goals while adapting to various contexts and

opportunities. Although EE programs can be effective in enhancing environmental stewardship attitudes and knowledge in learners, they often lack systemic evaluation, which can reduce their overall effectiveness (Ortega-Lasuen et al., 2023). As Augaure et al. (2017) suggest, programs with an Indigenous Science component require culturally responsive evaluation techniques that continuously support and track participants to better understand their progress and program strategies.

By assessing the implementation of programs in real-world settings, process evaluation provides timely insights into what works and the challenges that need to be addressed to improve delivery and ensure programs are on track to meet their goals (Carleton-Hug, 2010; Monroe, 2010; Ortega-Lasuen et al., 2023). Conducting process evaluation throughout the implementation phase allows for the efficient integration of feedback and necessary modifications, ensuring that programs remain effective, culturally responsive, and relevant (Chen, 2014). Given the complexity and evolving nature of braided EE programs, employing a developmental evaluation approach can be particularly beneficial, as its flexibility supports ongoing adaptation to meet the shifting needs of diverse school contexts (Quinn Patton, 2011). A detailed process evaluation of school-based braided EE programs would not only elucidate common concerns but also provide valuable insights into the general strengths and challenges of such programs.

Building on this need for detailed evaluation, this study explores the unique context of braided EE programs implemented by a predominantly white, non-Indigenous teaching team working in partnership with Indigenous educators. This collaboration bridges the gap between settler-led classrooms and Indigenous knowledge systems, offering a rare middle ground for understanding how these programs can be successfully introduced and adapted in mainstream educational settings. Additionally, comparing the implementation across two distinct contexts—

one where no prior braided curriculum exists and another where programs build upon established structures—allows for a nuanced understanding of how different school environments shape the adoption and adaptation of braided learning. Frameworks that incorporate planning, pedagogies, and assessments facilitate process evaluations that identify solutions to perceived barriers for outdoor learning and contribute to program evaluation research for EE and Indigenous-focused programs (Harris, 2023; Monroe, 2010; Shepherd & Graham, 2020; Waite et al., 2017). This longitudinal, two-year study enables continuous feedback loops and iterative improvements, offering insights that shorter-term or one-off programs may not capture. Evaluating the implementation of stewardship programs sheds light on the processes involved in cultivating stewardship values (e.g., caretaking, responsibility, respect), where research has tended to focus on outcomes, according to Dos Santos & Gould (2018). By focusing on this evolving process, this research contributes to a deeper understanding of how braided IWS programming can be refined and sustained over time, even in diverse and shifting school contexts.

The goal of this paper is to provide process evaluations of six school-based environmental education (EE) programs that braid IWS. This study distinguishes between Emerging and Mature educational contexts. The Mature context features an integrated curriculum that promotes experiential, braided, and community-engaged learning, supported by strong relationships to Indigenous educators and community members. In contrast, the Emerging context operates within a conventional, fragmented curriculum where EE is less integrated and typically absent. The process evaluations focus on the implementation, adaptation, and refinement of these programs in diverse school settings, aiming to:

1. Integrate multiple sources of data and examine how these programs are implemented with a focus on braided education that emphasizes experiential, outdoor, and community-engaged learning.

2. Compare and contrast implementation of braided EE programs across Mature and Emerging school contexts, considering variables such as time, curricula, class size, resources, and educator experience.

3. Identify key trends, strengths, and challenges in program implementation through integration of student and collaborator feedback and practitioner observations.

I explore how program characteristics impact implementation, discuss the evolution of programs through developmental evaluation approaches, and reflect on the challenges of collaborative and developmental evaluation in contrasting curricular settings. These evaluations not only highlight strengths and limitations but also offers insights into how these programs can be refined to better meet student needs. The findings are particularly relevant for educators looking to implement braided EE programs in mainstream school settings.

2.2 Methods

2.2.1 School contexts & program details

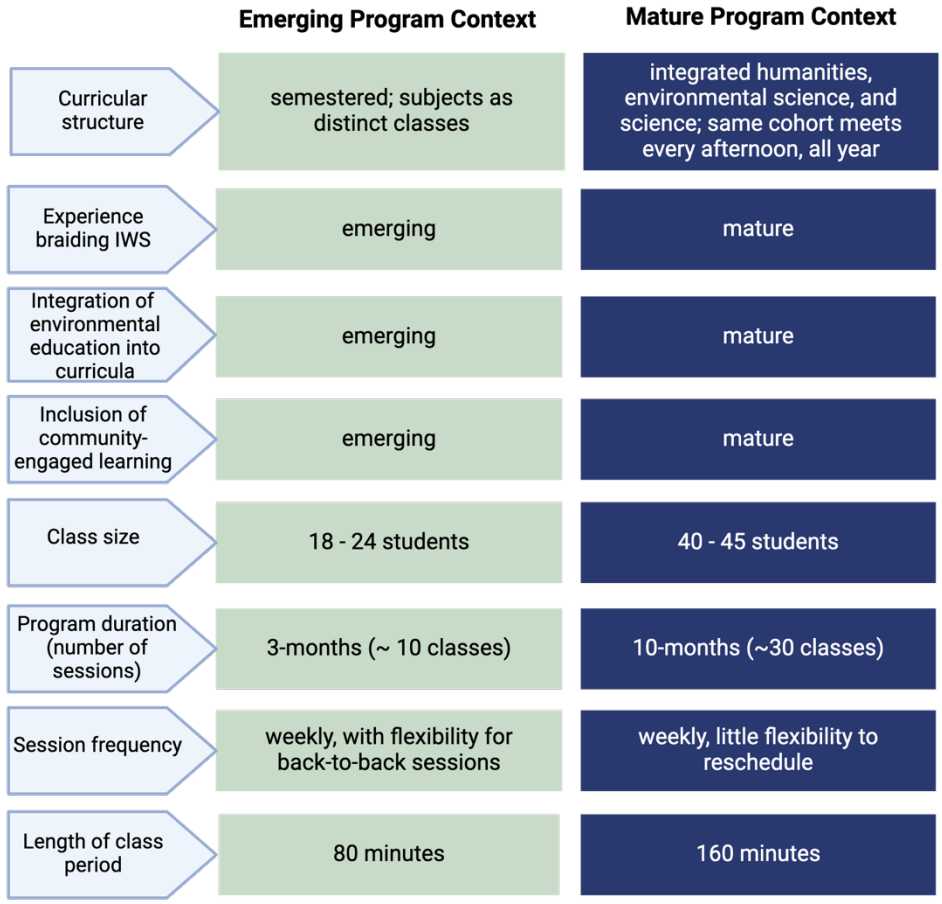
This study took place at two secondary schools differing in curricular structure, level of environmental education integration, experience with braiding IWS, and incorporating community-engaged learning (Figure 1). The "Mature" program context is a nationally-recognized integrated curricular program that integrates Humanities, Science and Environmental Science. A teaching team of three teachers plus an educational support stewards 40 to 45 Grade 9/10 students over two-years. Experiential, braided, and community-engaged learning are principles of the Mature-context curriculum and students are exposed to a variety of EE opportunities in addition to the programs presented in this study such as climate change education, gardening programs, and overnight camping trips. Relationships to district-level Indigenous educators and community members are strong, particularly with the Humanities teaching lead. In contrast, the "Emerging" context follows a conventional semester-based curriculum fragmented by subject where a main classroom teacher and an educational support

teaches a Grade 9 Science class of a typical size (16 to 25 students) for one semester (4-months), where EE, braiding IWS, and community-engaged learning are not typically implemented (Figure 2.1). By exploring how the differences between Emerging and Mature contexts influence both the implementation and process evaluation, this study aims to uncover the factors that either support or challenge the successful integration of braided EE programs across varied educational settings.

In the Emerging context, four distinct shorter-term (10-lesson/3-months) programs were developed and implemented over two years (one per semester). Each was taught to a different cohort of students occurring in either Fall or Spring and applying different topics with core pedagogies to varying degrees (Figures 2.2, 2.3). A short 5-day pilot program in June 2022 was conducted to get a sense of programming where no data was formally collected but helped shape future implementation. In the Mature context, two longer-term (30-lesson/10-months) programs were developed and implemented, preceded by a 3-month observation and relationship building period. For both contexts, curricula were developed with collaborative and community-engaged approaches garnering input from students, teachers, Indigenous educators and community members, and other community-based EE focused educators, put together formally by myself as the lead program coordinator. I also served as lead instructor in the Emerging context, and supportive educator (not the lead) in the Mature context. All programs share the same goals of enhancing environmental attitudes and knowledge, facilitating deeper relationships with nature, and engaging students in material through braiding IWS and applying desired pedagogies in respective contexts.

Figure 2.1

Program Context Characteristics



Note. Characteristics of two school contexts where the braided environmental education programs were hosted.

2.2.2 Evaluating program processes with developmental approaches

Gaining insight on program implementation trends, strengths, and challenges can be achieved through process evaluations. According to Chen (2014), process evaluations are geared at program refinement and can identify factors supporting or hindering program goals and processes through analysing information collected from different program team members such as participants, collaborators, and practitioners that take the form of written, verbal, or observation-based feedback processed in-situ or analysed retroactively. Because school-based settings are complex, involve shifting contexts and programs that unfold over time through collaborative input, process evaluations for this study were undertaken with developmental approaches.

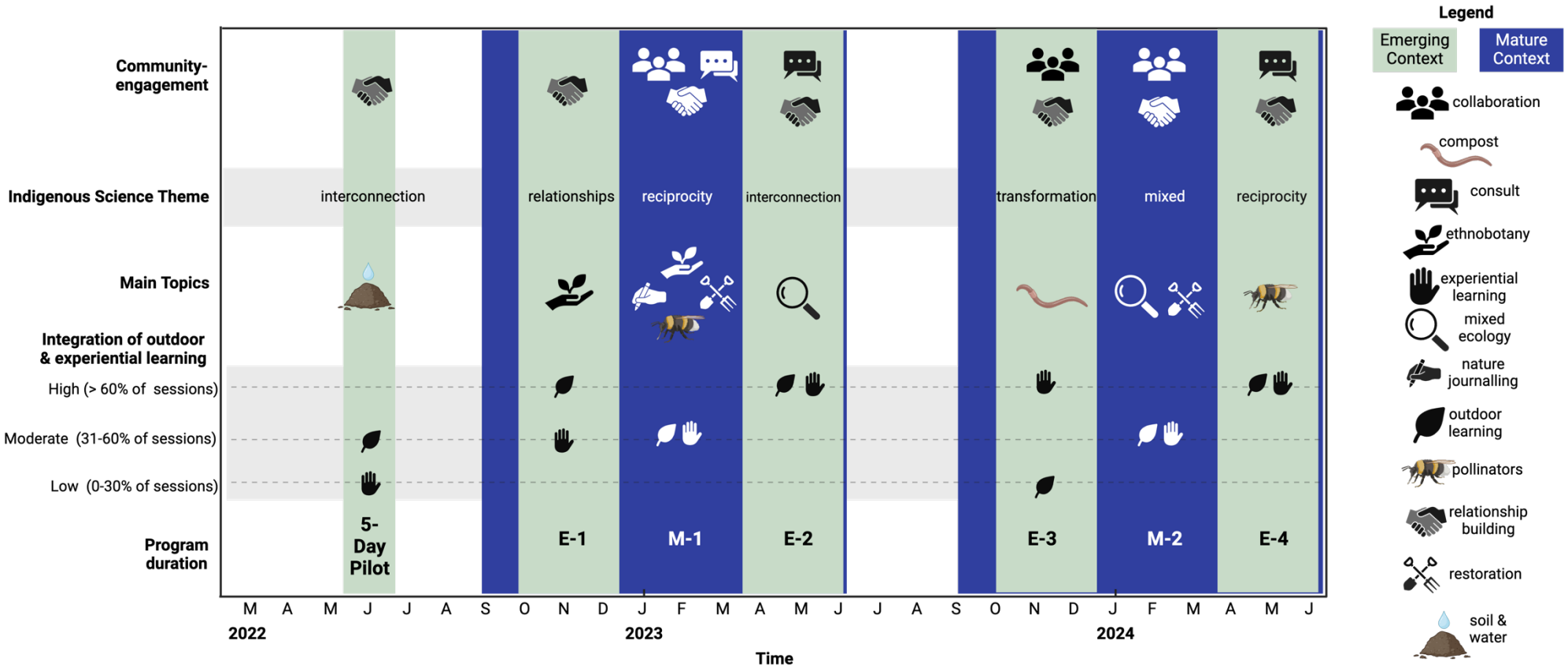
Developmental evaluation emphasizes learning through iterative feedback loops, participatory methods, adaptive management, exploratory techniques, and innovation and experimentation (Quinn Patton, 2011). In addition to program refinement, process evaluations can demonstrate program accountability, provide contextual information needed to interpret outcomes, and help secure funding for future implementations (Chen, 2014; Wildcat et al., 2014). Because EE scholars Ardoin et al. (2020), Fraser et al. (2015), and Jickling & Wals (2008), note a disconnect between intent and impact, and discourse and practice, conducting process evaluations with developmental approaches could provide the evolutionary perspective needed for program sustainability and contextual information for interpreting program impacts.

2.2.3 Data sources & analysis

For the process evaluations, aspects of the six implemented EE programs were documented and monitored to assess how programs were being implemented and whether implementation aligned with the general intentions of the programs: to deliver programs that emphasize experiential learning that braids IWS and incorporates community-engagement in order to enhance learners' environmental knowledge and attitudes, engagement with material, and relationships with nature. Monitored characteristics include implementation details specific to each program (Figure 2.2) and main pedagogies incorporated into each program (Figure 2.3).

Figure 2.2

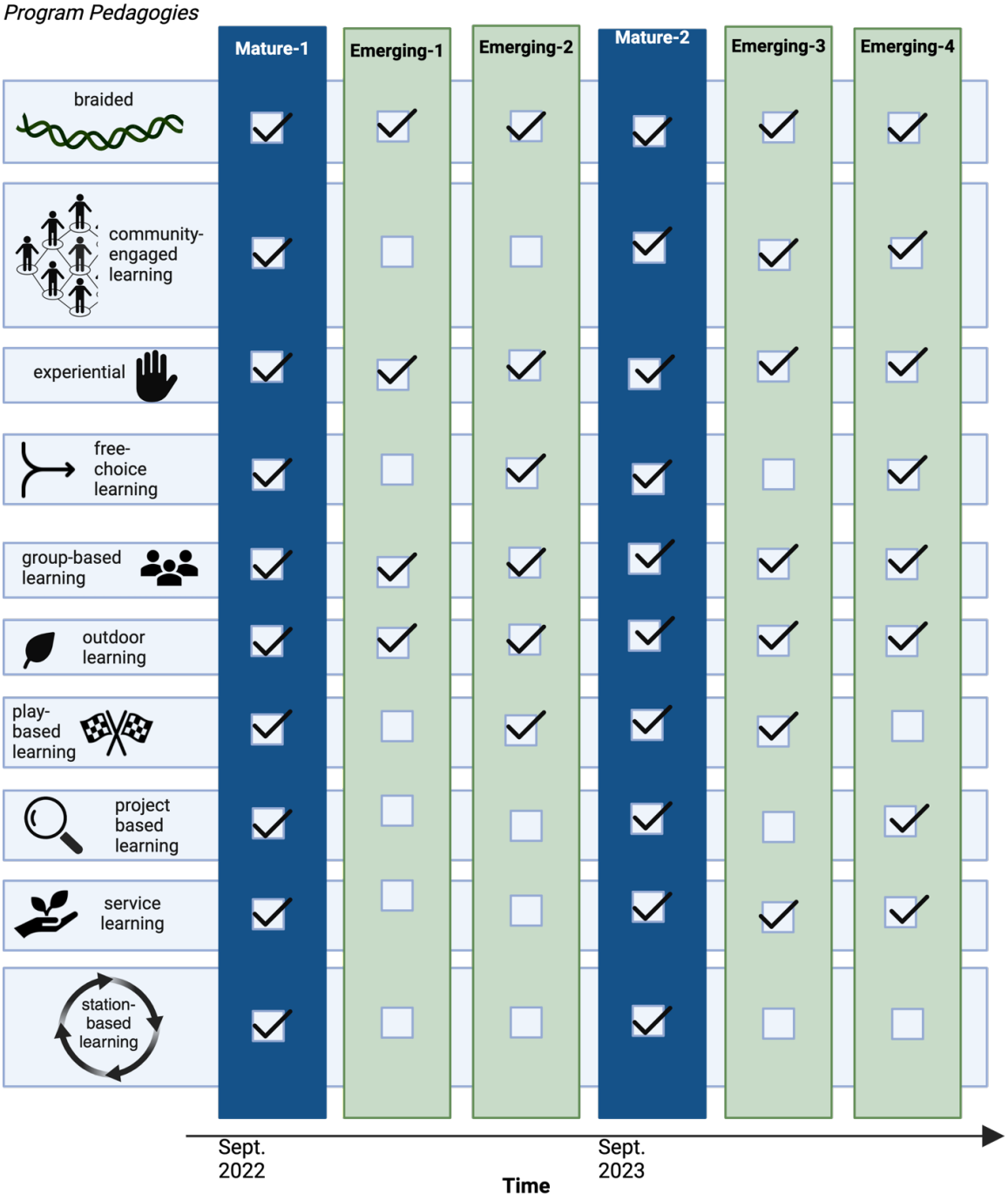
Program Implementation Details of Six School-based Braided Environmental Education Programs Developed with Community-engaged Approaches



Note. A timeline depicting implementation of two long-term programs in the Mature context (blue) and four short-term programs from the Emerging context (green) involving integration of outdoor and experiential learning, main topics and Indigenous Science themes, and levels of community-engagement

Figure 2.3

Program Pedagogies



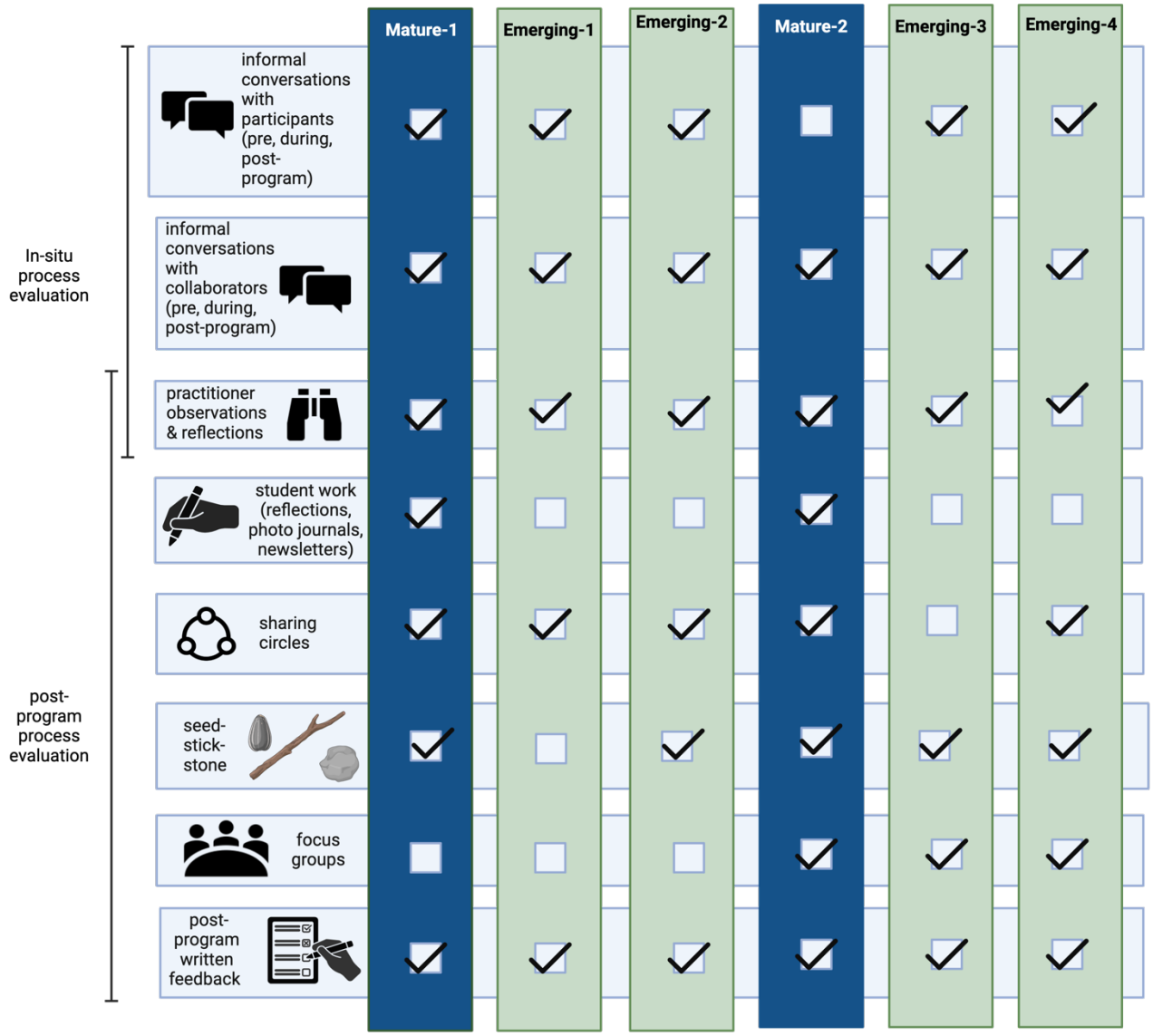
Note. Pedagogies included per program in Mature (blue) and Emerging (green) program contexts.

[2]

[2] See the glossary at the end of this chapter for a list of terms, such as the pedagogies mentioned in Figure 2.3.

Figure 2.4

Mechanisms of Process Evaluation



Note. Mechanisms of process evaluation conducted in-situ and post-program across the six braided environmental education programs taking place in Mature (blue) and Emerging (green) program contexts.

Process evaluation data were collected from three main sources:

- **Student participant feedback**: sharing circles, informal conversations, focus groups, qualitative survey data, journal entries and other student work, other evaluations (e.g., via collaborating nature sanctuary, host classroom).
- **Formal and informal collaborator feedback**: conversations, interviews, emails
- **On-site practitioner observations and reflections**

Figure 2.4 depicts the suite of process evaluation data collected, processed, and analysed for each program iteration. Given that process evaluation occurs as programs are underway, data collection and analysis were iterative and ongoing. Conclusions from process evaluations were drawn both in-situ as programs occurred and retroactively upon program completion. In-situ process evaluation occurred during or after the program sessions through observations and conversations with collaborators and participants, and tended to capture more overt implementation successes and challenges. The more subtle nuances of program implementation were captured with retroactive evaluation—reading and analysing written feedback from student work, post-program surveys, or practitioner reflections, and revisiting verbal feedback from post-program sharing circles, focus groups, and conversations with collaborators. For example, in the Mature-context, student work conducted during the program (journal entries, photo diaries, newsletters) was loosely skimmed at mid-points and thoroughly analysed post-program. Less student work was integrated into the Emerging contexts; however, any worksheets or reflections from Emerging contexts were analysed post-program along with the written survey feedback responses.

Qualitative data analysis was conducted with content analysis which focuses on recurrence of comments and groups similar comments into categories or main themes (Julien, 2008). For each of the six programs, student feedback (written surveys responses, journal entries, photo diaries, focus groups) was transcribed. A first pass of rough coding was conducted to sort comments related to implementation strengths (and factors supporting implementation), challenges (and factors hindering implementation), or null comments. A more precise round of coding occurred through grouping similar comments within the “strengths” category. For example, comments mentioning positive aspects of being outside were grouped together under

“outdoor learning” or comments reference learning with friends were grouped under “social aspects”. This sorting process was repeated for comments detected in the “challenges” group. Any emergent or useful findings from the group of null comments were noted. Written practitioner notes and reflections were scanned and assessed for recurring comments or themes across different program sessions. Collaborator feedback was analysed in a similar way; because collaborator feedback for process evaluation was largely conducted through informal conversations after lessons, collaborator input was incorporated into written practitioner reflections. Qualitative data were integrated to further solidify main themes, such that any comments from practitioner reflections and collaborator feedback that aligned with categories generated from student feedback were added into that category.

Process evaluations undertaken with developmental approaches emphasize program refinement and growth. Understanding how programs evolved as a result of process evaluation can be facilitated through tracking the changes in program characteristics over time. In the section below I discuss program trends and how key program characteristics such as outdoor and experiential learning, community-engagement, topics and Indigenous Science themes changed over the two years in which the programs were implemented.

2.3 Process Evaluations: Findings & Discussion

Building on the methods described, the following sections present key findings from the process evaluations, detailing how braided EE programs evolved over time in both Emerging and Mature contexts. These findings focus on trends in program implementation, identifying both strengths and challenges, and providing insights into how the contexts shaped the adjustments and adaptations of each program. Key differences between contexts are summarised in Figure 2.5.

2.3.1 Program trends & implementation changes

Main implementation details of the six school-based environmental education programs are depicted in Figure 2.2. Core pedagogies for the braided programs were to situate learning outdoors and implement experiential learning. Comparing the two contexts, the Mature-programs are more stable in outdoor and experiential learning, but as noted by Chen (2014), more stable program components are to be expected for mature programs. As dictated in program development conversations with collaborators, the sessions were meant to be split such that sessions during the winter months took place indoors (~ 50% of the lessons or 15 classes) which is consistent with past program implementation. The Emerging program context paints a more dynamic picture. The pilot, though short (5-days), was valuable from an implementation perspective. A main implementation issue detected through the pilot was time management—it was a challenge getting students out of the classroom on time resulting in many of the sessions being indoors. A second challenge revealed through the pilot was the activities. Although the curriculum was reviewed by a curriculum developer with experience of Indigenous-focused content and included Western Science skills and an experiential outdoor activity (e.g., soil sampling), in practice not enough students were included in the soil sampling given the limited number of augers, and the quality of nearby soil made it challenging to teach concepts around soil science. Main feedback from the pilot included situating more learning outdoors and focusing on local plants.

Such feedback gave rise to characteristics of Emerging-1, which there is a noticeable jump in both levels of experiential learning and outdoor learning. Focusing on ethnobotany allowed for students to learn about local plants. In groups, students matched content cards and engaged with plants and books to deduce which content cards belonged to which plant. However, given the Fall season, cold weather posed the most frequently cited implementation challenge.

Moving forward, the level of outdoor learning in the Emerging contexts mirrored the seasons, where there is a noticeable drop in outdoor lessons for the next Fall implementation (Emerging-3; Figure 2.2). Learning from the activities taking place in Mature-1, and after trial-and-error with Emerging-1, more experiential, skill-based activities were consistently incorporated into the Emerging context (Emerging 2, 3, 4).

Program topics were usually dictated by student or collaborator feedback, and the current opportunities based on community relationships or time of year. From there, complementary Indigenous Science themes were chosen for that program based on existing resources for educators, such as *First Peoples Secondary Science* (FNESC, 2019). For instance, the partnering nature sanctuary in the Mature context has both a pollinator patch and restoration program, which served as half of the topics in Mature-1's curricula, and restoration carried on as a strong component of Mature-2. Composting emerged as topic for Emerging-3 based on collaborator feedback and time of year. Composting and decomposition have strong ties to the Indigenous Science theme of transformation and allowed for experiential learning that could take place indoors. However, post-program process evaluations revealed many students would have preferred some outdoor learning, so situating the worm and compost bins outdoors is a consideration for future implementations of a similar topic.

Given the role of community-engaged learning in these braided EE programs, community-engagement (with non-main collaborators) was an ongoing process. Relationship building occurred during every program through check-ins by way of email or spontaneous encounters at community events. Opportunities to collaborate with Indigenous community members (Emerging-3) or scientists from local organizations (Emerging-4) were based on funding availability, which was not guaranteed for each program cycle. As relationships

deepened between the program coordinator and a key Indigenous educator, more of a consulting/mentoring relationship developed, where the Knowledge Keeper weighed in on certain topics, activities, or processes for programs. Engaging the district-level Indigenous educator around once per program was the general goal, and acting on opportunities to collaborate with Indigenous community members or other experts when the working relationship would be mutually beneficial became general goals for community-engagement.

2.3.2 Pedagogies were implementation strengths across programs

Teacher collaborators in both contexts voiced indicators of implementation success as students being on task, supporting each other through learning, and showing interest in the material. Aligning with feedback from students, implementation success is largely based on the pedagogies prioritized in these programs. Pedagogies that were distinct from students' typical experiences in their science classes—group and play-based learning, and outdoor, experiential and free-choice learning were cited across both contexts as being program strengths (when implemented). Students mentioned being able to learn with friends in groups they made themselves, learn through trivia games and scavenger hunts, learning outdoors, learning through hands-on activities that required engagement with local plants, animals, or learning materials (e.g., making compost bins) and having freedom to explore at their own pace as the most memorable and enjoyable aspects in several programs (Emerging-2, 3, 4; Mature-1,2). Free-choice learning enabled students to choose which activity they wanted to pursue in a particular session and involved feelings of freedom and autonomy. Collaborator feedback received after the completion of Mature-1 revealed that incorporating choice allowed students to feel more control over their learning experience, consistent with Falk's (2005) theory of free-choice learning. An implementation tweak moving forward involved incorporating more free-choice learning, which posed different logistical challenges given the different resources and times required for multiple

simultaneous activities. Free-choice learning was applied in Emerging-contexts in tandem with project-based learning, as a potential solution to student desires of having more time learning and having more, or more frequent, program sessions. Though outcome monitoring was not the focus of process evaluation, students in Emerging-2, -3, and -4 verbally reported that environmental attitudes were positively influenced, especially in terms of enhancing awareness and gratitude. Thus, the incorporation of project-based learning as a type of free-choice learning served the dual purpose of injecting autonomy into the curriculum and offering student-led experiences in which personal relationships to the natural world could be developed.

Braided pedagogy also played a major role in implementation success, although it was more subtle or not reflected as overtly in student feedback. A recurring observation of mine was how braided pedagogy gave programs structural and relational integrity through carrying out Indigenous Science opening and closing protocols. Session openings often included some combination of a land acknowledgement, opportunities for learners to nurture individual relationships to land (e.g., introducing oneself, stating intentions), reflecting on gifts received from nature and responsibilities that comes with knowledge and reception of these gifts, analyses of settler colonialism as roots of the current environmental crisis, and a preamble linking the Indigenous Science theme to the Western Science topic to be covered. Closing protocols involved a debrief of what was learned and experienced or a gratitude sharing circle. As relationships between myself and Indigenous educators and community members deepened, more local protocols were learned and used with permission, which occurred through attending community events, engaging in workshops, and informing collaborators of program updates every few months over one year.

Since EE was novel for many students in the Emerging context, creating routines to begin and end learning helped create consistency and set expectations for learners. Structuring sessions with Indigenous Science protocols provided not only the foundational pillars for effective implementation but also a gateway to the relational and reflective processes essential to Indigenous learning—a key principle in Indigenous education, as noted by Cajete (2010). Because the Emerging context was a single subject taught by a single person—compared to the interdisciplinary program taught by a teaching team in the Mature context—the Emerging context was inherently more flexible. Thus, structuring lessons consistently and creating certain routines were easier to implement in the Emerging context. Plus, the Mature context involved station-based learning which added another temporal constraint for shuffling students out of the classroom and then to different stations at certain times. Thus, opening and closing in circle was not always possible in the Mature context. However, braided styles of learning were woven in different ways, such as through the strong Indigenous education component in the Humanities portion of the curriculum which emphasized relationship building with community and other Indigenous styles of learning.

2.3.3 Implementation challenges across programs

While implementation strengths were based mainly on the program pedagogies, implementation challenges were more diverse. An implementation challenge experienced in both contexts was related to the level of content being delivered during program sessions and how topics were (or were not) covered. Finding the balance of breadth and depth, and instruction and exploration, are challenges shared by other outdoor environmental educators, such as Waite et al. (2017), and were resolved through trial-and-error, keen observation, and continuous check-ins with collaborators. About mid-way through Mature-1 the spacing of content and schedule of station-based learning were shifted by allotting more time at each station and dedicating one lesson

every month or so to work on cumulative student assignments (photo diaries), plus a review class at the end of each term. Review classes in the Mature context were held every 3-months or so and occurred once per program in the Emerging context—near the end of the programs for Emerging-1, -2, and -3, and mid-way for Emerging-4 as a gateway for students to choose projects. In the Emerging context, practitioner observations and collaborator feedback revealed that successful implementation of outdoor learning gained momentum in Emerging-2, largely due to better spacing and delivery of content coupled with more consistent weaving of Indigenous Science.

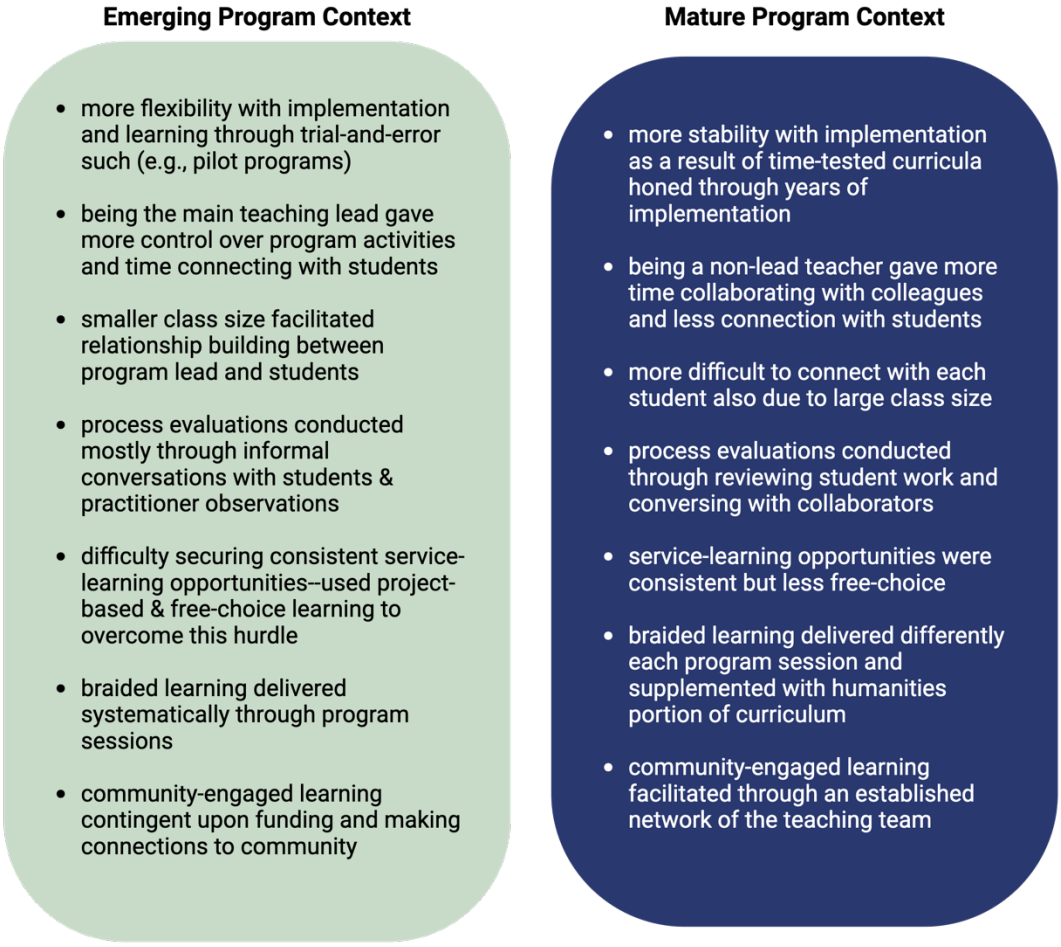
In the Emerging context, main challenges revolved around mechanisms of process evaluation and integrating service-learning. Service-learning is a core pedagogy in the Mature-context—offering students opportunities to learn through real world situations and have an active role in making a noticeable different in one's environment, such as through ecological restoration and removal of invasive species as in Knackmuhs et al. (2017). The close connections to the nature sanctuary permitted the inclusion of ecological restoration. However, in the Emerging-context, the lack of administrative power as an external community member (graduate student) posed challenges to orchestrating consistent community-based and service-learning opportunities. Finding creative pathways to service learning, such as through project-based learning in Emerging-4, overcame curricular constraints and gave students the opportunity to steer their own learning.

A second implementation challenge was obtaining process evaluations in the Emerging context. A significant advantage of the Mature-context where EE is already integrated is the alignment of formative assessment that can also serve as process evaluation. In Mature-1 and -2 formative assessment took the form of more frequent (bi-weekly) journal entries on Google

Classroom related to a topic learned in the program and less frequent (once per term) photo journals or newsletters that served as cumulative assessments, where photos, notes, and insights from weekly student visits to the nature sanctuary were synthesized in these assignments. Post-lesson reflections were intended for Emerging-1 and attempted again for Emerging-2. However, given the time of day and day of the week, students did not have capacity to engage with a post-lesson prompt, nor were these cohorts fond of reading and writing. As a result, process evaluations in the Emerging-context shifted to opportunistic conversations during and after programs where the program coordinator would mingle with students, support their learning, and ask about most and least enjoyable aspects of the lessons or what could be done to make it better. Although adapting with verbal process evaluations in Emerging-contexts meant employing different process evaluation techniques than those conducted in the Mature-context, the verbal approach aligned more closely with Indigenous pedagogy and evaluation techniques (Hudson et al., 2017). Thus, the two educational contexts present implicit trade-offs and offer different opportunities for process evaluation. The larger number of students in the Mature-context resulted in less face-to-face mingling, favouring more written feedback for process evaluation, while the Emerging-context favoured more informal verbal feedback and less written feedback in the form of student work. The different circumstances in the Emerging and Mature contexts highlights the benefit of using developmental evaluation, where different evaluation techniques are supported in different contexts for the same family of programs (Quinn Patton, 2011).

Figure 2.5

Key Implementation Differences Between Curricular Contexts



Note. Summary of key differences between the Emerging- and Mature-educational contexts in terms of conducting process evaluations for school-based programs that braid IWS and focus on experiential, outdoor, and community-engaged learning.

2.4 Caveats & Considerations

While this family of programs offer insight into implementing braided EE programs in school-based settings, some caveats or considerations are worth mentioning. The first is around the "learning feedback loops" of implementation and process evaluation. Learning feedbacks are a hallmark of developmental evaluation (Quinn Patton, 2011). Timely feedback is helpful for identifying and resolving implementation issues. In this study, both timely on-the-ground feedback and retroactive evaluation were used. As mentioned above, in-situ feedback seemed to

capture the overt success or challenges related to implementation. More subtle nuances of program implementation or participant's experience of program implementation were analysed retroactively. Though not entirely problematic, it might have been more beneficial for implementation if the feedback were analysed in real-time. For instance, if journal entries were written every other week, analysing entries as they came in instead of reading them in bulk at the end of the program could have identified implementation-specific strengths or challenges in a timelier manner in which action could be taken to rectify implementation. The benefit of retroactive evaluation was that patterns and themes were more easily detected through analysing the bulk of feedback (practitioner observations, student and collaborator feedback) in sequence.

A second caveat is the multi-purpose role I played as the program coordinator, and the limitations in evaluative capacity that come with being a program instructor, observer, and evaluator in community. Being on-site provided rich contextual information that allowed for a deeper interpretation of program implementation and facilitated opportunistic program evaluation, which was critical for the Emerging-context, where formative assessments were not present in the curriculum. However, having these multiple roles comes with limitations, such as potential for a positivity bias (i.e., emphasizing positive aspects or outcomes while overlooking areas needing improvement) or the emergence of what Reid (2019) describes as "blank, bald, and bright spots" within the curriculum and programming. These "spots" traditionally refer to environmental education (EE) topics that we know enough to question but not fully understand (blank), areas we need more information on to inquire further (blind), topics that are repeatedly pursued in research (bald), or topics that inspire innovation (bright). While this framework is typically applied to environmental education *topics*, it can also serve as a framework for reflecting on our own positionality, biases, and assumptions that may influence the curriculum or

evaluation. For example, as someone who stutters, I reflected on how my own high school experiences subconsciously shaped my desire to develop curricula that minimized public speaking. In the pilot program, I identified this as a "blind spot" because the programming unintentionally lacked opportunities for students to engage in relational communication and missed an opportunity to honour the oral tradition of Indigenous education. Upon reflection, I intentionally incorporated more relational approaches in the next cycle of programming, while remaining mindful of the need to avoid harm to students with speech impediments. Further, "bright spots" might represent personal passions that educators pursue; "blank spots" could indicate areas we are aware of but wish to explore further, potential collaborations, or activities or evaluation approaches we are curious about trying; and "bald spots" might include practices or activities we habitually default to, although not inherently detrimental. This framework encourages reflexivity in curriculum development, which can reinforce culturally responsive approaches to education. However, the community-engaged and collaborative methods through which these programs were developed—combined with the fact that most teaching in the Mature-context was led by a collaborator—helped mitigate the risk of my own "blank, bald, bright, and blind" spots dominating the curriculum.

A third caveat comes from the lack of objectivity in evaluating the integrity of certain pedagogies, such as braided pedagogy, which is further complicated by my positionality as a non-Indigenous person. McKegg (2019) emphasizes that reflexive practices are critical for culturally responsive evaluators; reflecting on how privilege and assumptions may be influencing program delivery, and truly recognizing and acknowledging limitations in being able to engage with Indigenous content and epistemologies, is a continual process that must be revisited over time. Carroll et al. (2020) offer that *productive pausing* can help settlers move through the

discomfort of engaging with Indigenous content and epistemologies. Additionally, leaning on Indigenous literature for guidance on braiding IWS and engaging in open dialogue with both Indigenous and non-Indigenous collaborators further supported implementation of braided pedagogy in the programs.

2.5 Significance

These findings contribute to EE by offering evidence-based insights into effective practices, cultural responsiveness, practical challenges, and the importance of adaptability and feedback in EE. Students particularly valued hands-on learning, group interactions, and free-choice activities. Understanding which pedagogic approaches resonate most with students can guide educators in designing more engaging and impactful EE programs (Monroe & Krasny, 2016). Incorporating Indigenous Science protocols and perspectives fostered meaningful relationships with the material, land, and program community members as well as provided much-needed anchor points during implementation. A key contribution of this work is the application of developmental approaches to refine and evaluate braided EE programs. These approaches enable iterative adjustments to delivery, balancing breadth and depth while ensuring that core program promises (e.g., experiential, outdoor, community-engaged) are met. My active involvement with the community and program activities facilitated timely feedback integration through in-situ process evaluations. Finally, the adaptive nature of developmental evaluation allowed for tailoring programs to different educational contexts, specifically by recognizing and addressing the unique challenges faced in both Emerging and Mature contexts. This knowledge enriches the field of EE by providing an example of how non-Indigenous educators can engage with Indigenous Science programs and use developmental, community-engaged evaluation to scrutinize implementation, leading to more effective, inclusive, and adaptable programs.

2.6 Conclusion

This chapter presented process evaluations for six school-based environmental education programs that braided IWS, emphasizing experiential, outdoor, and community-engaged learning. Examining the intricacies of program implementation across two contrasting school contexts revealed strengths and challenges related to program implementation. Implementation challenges around content delivery were experienced in both Emerging and Mature contexts, and some adaptations for process evaluation and incorporating some pedagogies were needed in the Emerging context. Pedagogies prioritized in these braided EE programs emerged as program strengths in both contexts across all six programs. Using a developmental approach to process evaluation showcased implementation changes over time allowing for a more comprehensive understanding of how process evaluation can lead to program evolution. Insights gained from contrasting these contexts during process evaluation can serve as valuable implementation models, assisting in the effective integration of braided EE programs across diverse curricular settings.

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2.8 Appendix

Chapter 2 Glossary

Braided learning: A pedagogic approach that braids Indigenous and Western Science (IWS) perspectives and practices to provide a more comprehensive and inclusive curriculum, often involving knowledge keepers, community, holistic, relational, language, place, experiential, and ecological components (Snively & Williams, 2016).

Community-engaged learning: Learning that actively involves community members who are not typically part of mainstream school settings, fostering deeper connections and relevance (UVic's Community-Engaged Learning Office, 2024).

Community-engagement: the extent to which non-mainstream community members participate in program activities (development, implementation, evaluation), ranging from informing, consulting, involving, collaborating, and co-creating; often preceded by a relationship building period (UVic's Community-Engaged Learning Office, 2024).

Experiential learning: Learning through hands-on experience and active participation rather than passive receipt of information (Monroe & Krasny, 2016).

Focus groups: A semi-structured discussion with small groups of students facilitated by the program evaluator, to provide in-depth, contextual feedback that goes beyond survey responses. Focus groups are not anonymous or confidential.

Free-choice learning: Learning that allows individuals to direct their own educational experiences with an open or defined range of options, fostering autonomy and personal relevance (Falk, 2005).

Group-based learning: Learning that occurs within groups of students, emphasizing collaboration and collective problem-solving (Stern et al., 2014).

Indigenous Science theme: a central theme within the program that focuses on integrating Indigenous Science, often guided by resources such as FNESC's (2019) curricular guide on *First Peoples Secondary Science*.

Informal conversations: unstructured, spontaneous discussions with participants and collaborators occurring before, during, and after program sessions to gather qualitative insights and feedback for process evaluations (Chen, 2014).

Integration of outdoor and experiential learning: the extent to which a program incorporates outdoor and experiential learning activities categorized as low (0-30% of sessions), moderate (31 to 60% of sessions) or high (> 60% of sessions).

Main topic: the primary science topic or topics that unify the program such as soil and water, pollination, restoration, or general ecology.

Outdoor learning: Learning that takes place outside of the traditional classroom environment and involves engagement with the land. When outdoor learning incorporates Indigenous perspectives, peoples, practices, culture, and language, and aims to support Indigenous futurity, it is considered land-based learning (Tuck et al., 2014). Although our programs include elements of Indigenous pedagogy, we refer to them as "braided outdoor learning" rather than "land-based learning" because the programs are led primarily by non-Indigenous educators and are not exclusively focused on Indigenous pedagogy. This distinction reflects our recognition of the program's integration of Indigenous elements while acknowledging its limitations in fully embodying land-based learning.

Play-based learning: Learning through playful activities such as scavenger hunts, trivia, or other games, which encourage engagement and exploration (Stern et al., 2014).

Post-program written feedback: An extension of the survey, where students provide anonymous responses to complement the quantitative data gathered in the post-program survey.

Practitioner observations and reflections: Data collected by program practitioners through observing and reflecting on program activities, processes, and relationships. This approach aims to improve and refine program implementation and facilitate reflexivity in practice, allowing practitioners to critically evaluate their own roles, biases, and impact.

Program duration: the length of the program measured in months.

Project-based learning: Learning centered around a selecting, planning, implementing, and evaluating a specific environmental project with real-world applications, such as creating a community-map or designing a pollinator habitat, fostering practical application and problem-solving skills (Stern et al., 2014).

Seed-stick-stone: quick evaluation technique where students identify what they will remember (stick), what they found challenging (stone), and what they would like to learn more about (seed). This can be used for process evaluation post-lesson or outcome evaluation post-program.

Service-learning: Learning through active service to address real-world needs, integrating community service with academic learning (Merritt et al., 2017).

Sharing (talking) circles: Indigenous knowledge-sharing practice and culturally responsive evaluation technique where participants share their thoughts and experiences in a circular format, allowing for equal voice and limited cross-talk (Brown & Di Lallo, 2020).

Station-based learning: A method where students rotate through various stations, each focusing on different aspects of the activity, lesson, or program, beneficial for managing larger groups (Heather Coey personal communication, 2022).

Student work: Outputs from students including any reflections, journals, photo journals, work sheets, comments, and newsletters that demonstrate learning and help evaluate program impacts

Chapter 3

The use of multiple methods to evaluate impacts of braided environmental education programs on multiple dimensions of student learning

3.0 Abstract

In this study, I evaluate six environmental education programs that braid Indigenous and Western Science perspectives within contrasting curricular contexts to assess their impacts on student's environmental knowledge, attitudes, relationships with nature, and engagement with material. Utilizing pre-and-post program surveys alongside multiple sources of qualitative data, I identified experiential learning, exposure to novel plants and animals, and social relationships as key facilitators of learning across the four dimensions. Enhanced environmental awareness emerged as an unintended program outcome, and several barriers to achieving desired outcomes were noted. While surveys detected immediate gains in environmental knowledge, qualitative feedback from focus groups and open-ended survey responses provided deeper insights into changes in attitudes, relationships, and engagement. These findings emphasize the importance of employing multiple methods for a comprehensive understanding of program impacts, with a particular focus on qualitative approaches to ensure culturally responsive evaluation. The results indicate that braided, school-based programs can effectively cultivate environmental knowledge and attitudes, foster relationships with nature, and enhance engagement, though sustained programming is necessary to maintain these impacts.

3.1 Introduction

Environmental education (EE) is increasingly recognized as a vital tool for addressing the global environmental crisis by repairing and strengthening relationships with the natural world. By empowering learners with relevant knowledge and skills and opportunities to enhance environmental attitudes and awareness, EE aims to develop capacity at the individual and community level to engage in environmental stewardship (Ardoin et al. 2020; Swayze et al., 2009). As mentioned by Ardoin et al. (2018) and Steg (2016), school-based programs provide an accessible way to implement EE, reaching students at a formative stage in their development when environmental values and identities are being formed.

One promising approach to EE is the integration of Indigenous and Western perspectives, often referred to as braided education (Snively & Williams, 2016). This method leverages the strengths of both knowledge systems, offering holistic learning through teaching principles, perspectives and processes associated with Indigenous and Western Sciences (IWS). Western Science is adept at diagnosing and analysing environmental phenomena and problems, whereas Indigenous Science extends the scope of WS through providing sustainable solutions that lie at the intersection of culture and nature often based on principles of responsibility, relationships, reciprocity, and respect for other beings (Kimmerer, 2012). As colonization and colonial practices are root causes of the ecological crisis, Indigenous perspectives can play an important role in effective EE (Cajete, 2010; Charles & Cajete, 2020; Hunter & Richmond, 2022; Simpson, 2002; Stein, 2019; Sutherland & Swazye, 2012). Indigenous pedagogies in braided education emphasize the interconnectedness of all life forms and advocate for learning that engages the physical, intellectual, emotional, and spiritual dimensions of the learner through education that involves land, Indigenous contexts, and Indigenous processes (Cajete, 2000; Simpson, 2014).

Because Indigenous pedagogy posits that deeper learning can occur only when all four dimensions of the learner—physical, intellectual, emotional, and spiritual—are engaged (Cajete, 2000), there is merit in unpacking these dimensions of learning to provide a more comprehensive understanding of learning and elucidate mechanisms at play in braided education in school settings. In the context of EE, these dimensions could translate to promoting physical engagement with material, enhancing environmental knowledge, fostering environmental attitudes, and nurturing relationships with nature, respectfully. There are various pedagogic approaches to engage these dimensions and carry out a braided education. Experiential learning, learning that has real world application (service-based learning), situating learning outdoors or on the land, and emphasizing community-engagement, where community can be human or more-than-human entities, are key pedagogies for programs that include Indigenous Science (Bang & Medin, 2010; Kapyrka & Docksatator, 2012; Kimmerer, 2012).

Environmental stewardship and caretaking are conceptual bridges between Indigenous and Western Science (Shermata, 2018; West et al., 2018; Whyte et al., 2016). For instance, both paradigms recognize: the synergistic potential between intellectual and emotional domains in facilitating sense of relationship or responsibility to the natural world; the role of critical place-based education as a pathway to cultivating care; and the importance of physically reconnecting people to land as a means of facilitating the creative engagement process unique to each learner and cultivating deeper relationships with the natural world (Cajete, 2000; Chawla, 2021; Diver et al., 2019; McKeon, 2012; Littledyke, 2008;West et al., 2018). Evaluating programs revolving around environmental stewardship are promising for contributing to an understanding of how braided EE can impact learners on physical, intellectual, emotional, and spiritual dimensions.

In this study, I investigate impacts of school-based environmental education programs that braid Indigenous and Western Science perspectives in schools differing in curricular context (e.g., program duration, level of experience braiding IWS, season of implementation). My primary goal is to determine whether these programs can positively impact learning across multiple dimensions: engagement with material (physical), environmental knowledge (intellectual), environmental attitudes (emotional) and relationships with nature (spiritual). I employed a multiple-methods approach, utilizing pre- and post-program surveys, focus groups, written responses, informal conversations, and student work to gather comprehensive data. Through triangulating these data, I assess the impact of these programs in both contexts and identify main factors facilitating or impeding learning. Considerations related to evaluating braided programs using multiple methods are discussed. By understanding mechanisms that enhance learning across multiple dimensions, grassroots programs in diverse mainstream school settings can work to repair and strengthen relationships with the natural world, in favour of social and planetary wellness.

3.2 Methods

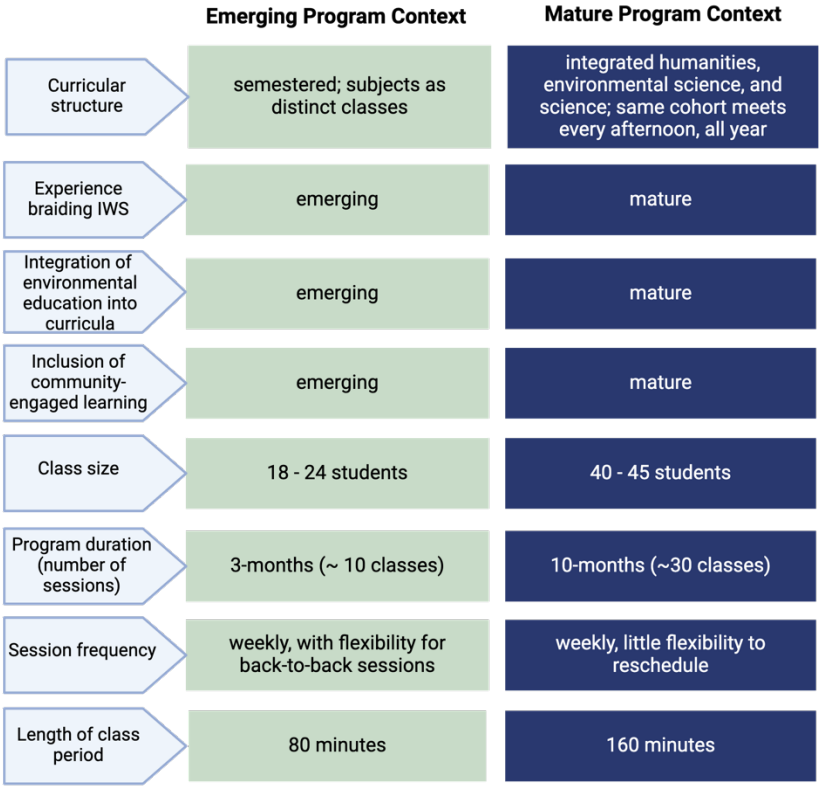
3.2.1 Educational context

This study took place at two secondary schools differing in curricular structure, level of environmental education integration, experience with braiding IWS, and incorporating community-engaged learning (Figure 1). The "Mature" program context is a nationally-recognized integrated curricular program that integrates Humanities, Science and Environmental Science. A teaching team of three teachers plus an educational support stewards 40 to 45 Grade 9/10 students over two-years. Experiential, braided, and community-engaged learning are principles of the Mature-context curriculum and students are exposed to a variety of environmental education opportunities in addition to the programs presented in this study such as

climate change education, gardening programs, and overnight camping trips. Relationships to district-level Indigenous educators and community members are strong, particularly with the Humanities teaching lead. In contrast, the "Emerging" context follow a conventional semester-based curriculum fragmented by subject where a main classroom teacher and an educational support teaches a Grade 9 Science class of a typical size (16 to 25 students) for one semester (4-months), where environmental education, braiding IWS, and community-engaged learning are not typically implemented (Figure 3.1). The various activities conducting across programs are shown in Figure 3.2.

Figure 3.1

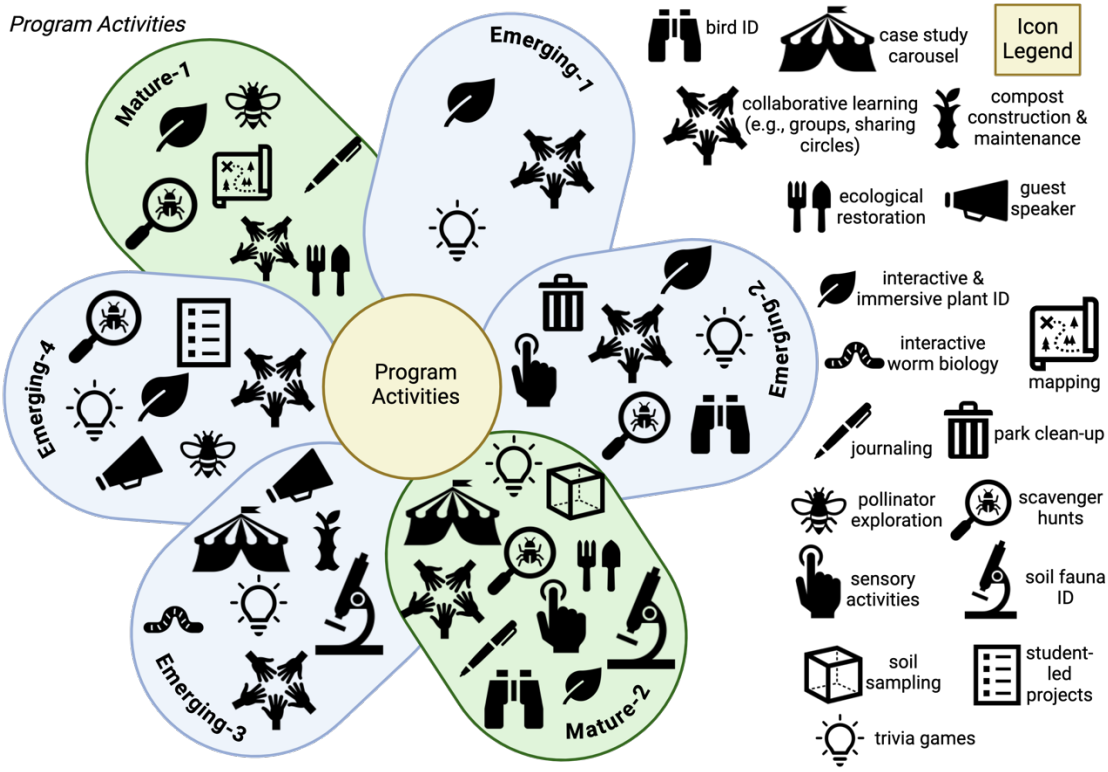
Program Context Characteristics



*Note.*Curricular contexts of classes participating in this study of evaluating environmental education programs that braid Indigenous and Western Science to assess impacts on multiple dimensions of student learning

Figure 3.2

Program Activities



Note. Learning activities conducted within each of the school-based braided environmental education programs.

3.2.2 Data sources

Mixed methods approaches were used to assess how these six school-based braided EE programs impacted learning across multiple dimensions. All programs used pre- and post-surveys with quantitative and qualitative responses, whereas other evaluation techniques were applied as appropriate and possible including post-program focus groups, informal conversations, and some photo and written journals. Post-program interviews with key collaborators were also conducted in previous program phases; any feedback which could help interpret program impacts were included in the analysis when relevant.

3.2.2.1 Survey instrument development & analyses

A 20-question 5-point Likert-style survey instrument was developed by drawing from multiple existing surveys (e.g., Ashurst et al., 2008; Salazar et al., 2020) and adding some collaborator-

specific intentions (Table 3.1). Surveys were chosen as an evaluation tool alongside qualitative methods provide an alternative perspective of program impacts. Plus, using multiple sources of information aligns with principles of both Indigenous education (Kimmerer, 2012) and program evaluation (Quinn Patton, 2011). I opted to devise an instrument specific for this work to explore learning from a holistic and multi-paradigmatic perspective and allow the inclusion of collaborator specific questions. Five questions from each dimension were included: engagement with material (physical), environmental knowledge (intellectual), environmental attitudes (emotional), and relationships with nature (spiritual). These four dimensions of learning were selected to align with the principle in Indigenous pedagogy that true learning occurs holistically, encompassing the spiritual, physical, emotional, and intellectual aspects of the learner, as emphasized by Battiste (2013), Cajete (2000), and Kimmerer (2012).

Surveys were administered before the program began and at the end of the final session. After survey data were entered and cleaned, Wilks-Shapiro tests were conducted to test for normality and pre- and post-program score differences were calculated by dimension for each program. Paired t-tests were computed for each dimension to detect significant differences between pre- and post-program scores. To determine whether learners in the Mature-context had higher baseline scores than those in the Emerging-context, unpaired t-tests were conducted on the pre-program scores between the two groups. An unpaired t-test was chosen because the two contexts consist of different students, making their scores independent of each other. An analysis of variance (ANOVA) was computed to test for significant impacts of program duration (3-months; 10-months) and season (Fall, Spring, All-year). Since duration represents the concept of ‘context’ (mature/emerging) mathematically, context was excluded from the ANOVA model. Tukey’s multiple comparisons of means were computed to detect which program characteristic

had the biggest effect on how the scores changed from pre-test to post-test. Survey dimensions were evaluated for Cronbach's alpha (Salazar et al., 2020) to assess the internal consistency reliability of the items—that is, assessing how closely related the items are as a group.

Table 3.1. An example of the 20 Likert-style questions on the pre-and-post-program surveys where students ranked how well they agree with each statement on a 5-point scale**,** sorted by dimension: physical (engagement with material), emotional (environmental attitudes), intellectual (environmental knowledge), spiritual (relationships with nature).

Question	Dimension
I am interested in doing scavenger hunts as a way to connect with nature.	Physical
I often feel a sense of kinship and interconnectedness with other plants and animals.	Spiritual
It is important that we each act responsibly and do our part to take care of the natural world.	Emotional
I feel comfortable describing ethical guidelines for interacting with nature.	Intellectual
Reflecting on what I learned after the lesson helps me clarify my learning.	Physical
I feel a desire to protect the natural world.	Spiritual
I often feel that we should treat other plants and animals with respect because we depend on them so much.	Emotional
I feel that my actions impact the health of the environment.	Spiritual
I feel I have the skills and knowledge to describe how to do a tree inventory.	Intellectual
I often find it easier to learn outdoors than in the classroom.	Physical
I recognize and appreciate the intelligence of other living organisms.	Spiritual
I am interested in learning about pollinators and their plants.	Physical
I often feel a strong sense of care towards the natural environment.	Emotional
The concern/compassion I feel for non-human beings in the natural world motivates me to want to take care of them.	Emotional
I feel comfortable describing the types of animals and plant habitats we have at the park.	Intellectual
I feel that Indigenous perspectives and knowledge contain important information about the environment and ways of knowing nature that everybody needs to know.	Intellectual
My relationship to nature is an important part of me.	Spiritual
I feel I can describe key aspects of Coast Salish peoples' ethnobotany, including medicinal, edible, and technological uses of native plants.	Intellectual
I often feel appreciative and grateful for all the natural world does for us.	Emotional
I enjoy learning about environmental science and nature.	Physical

3.2.2.2 Qualitative data sources & coding

Context-rich participant responses were captured via in-situ conversations during program implementation, student work, post-program focus groups, and written responses on the post-program survey. Although student work varied depending on the program, the bulk of student work came from Mature program settings where journal prompts were conducted as student assignments outside of program sessions and collected bi-monthly in both years (Mature-1 and -2), versus the Emerging program context which relied on worksheets or projects conducted within program sessions. On post-program surveys, students answered open ended questions about what aspects of the program they enjoyed most or least, and various questions around whether the program had impacted knowledge, attitudes, relationships or views around caretaking. For redundancy, focus groups asked similar questions around the four dimensions with room for general comments around what worked well and what could be changed for next time (Appendix 3.2). Focus groups were not recorded; the program evaluator asked questions, took notes, and mirrored back student responses to assess accuracy at the end of each focus group. For ease of coding, all data were cleaned and put in a single document: written survey responses and focus group data were transcribed; notes from in-situ conversations were uploaded, and student work was downloaded.

Qualitative data were coded manually with a hybrid deductive-inductive coding approach (Blair, 2015). Because the survey was designed to assess student outcomes on four dimensions of learning (environmental knowledge, environmental attitudes, relationships with nature, engagement with material), these four dimensions served as the broad coding categories upon which the survey responses and student work were sorted into. A first pass at coding sorted feedback into factors that supported the outcome (knowledge, attitudes, relationships, engagement) or factors that impeded it. Quotes from focus groups and written survey responses

were extracted and included under that coding category. Feedback that fell outside the categorizations of the four dimensions were further sorted into main and sub-themes with inductive coding. Since similar themes emerged under the separate categories in the coding template, a second round of coding worked to create categories. A third round of coding identified subthemes through recurring feedback within those main themes (Appendix 3.1). Often, a main theme was identified when it was found to impact each of the four dimensions of learning. Thus, coding began as deductive with categories as main themes, and became inductive as main themes began to emerge within the initial codebook.

3.3 Results

3.3.1 Survey

The analysis of pre- and post-program surveys indicates significant gains in environmental knowledge across all programs ($p < 0.05$). However, changes in environmental attitudes, relationships with nature, and engagement with material were not statistically significant, except for increases in Mature-2 (attitudes) and significant decreases in Emerging-3 (Table 3.1). Pre-test scores in Mature-1 and -2 were significantly higher than those in Emerging-1, -2, and -3 ($p < 0.05$). In terms of program characteristics, the ANOVA and Tukey's test revealed that Fall season, Emerging context, and short-duration are all significantly associated with larger gains from pre to-post program. In other words, score increases were relatively larger for students learning in the Fall and for students in shorter duration (Emerging-context) programs. When testing for Cronbach's alpha, each dimension was found to have an alpha above 0.95, indicating that the survey items within each dimension are consistent with each other, measuring the desired construct (variable of interest).

3.3.2 Qualitative data

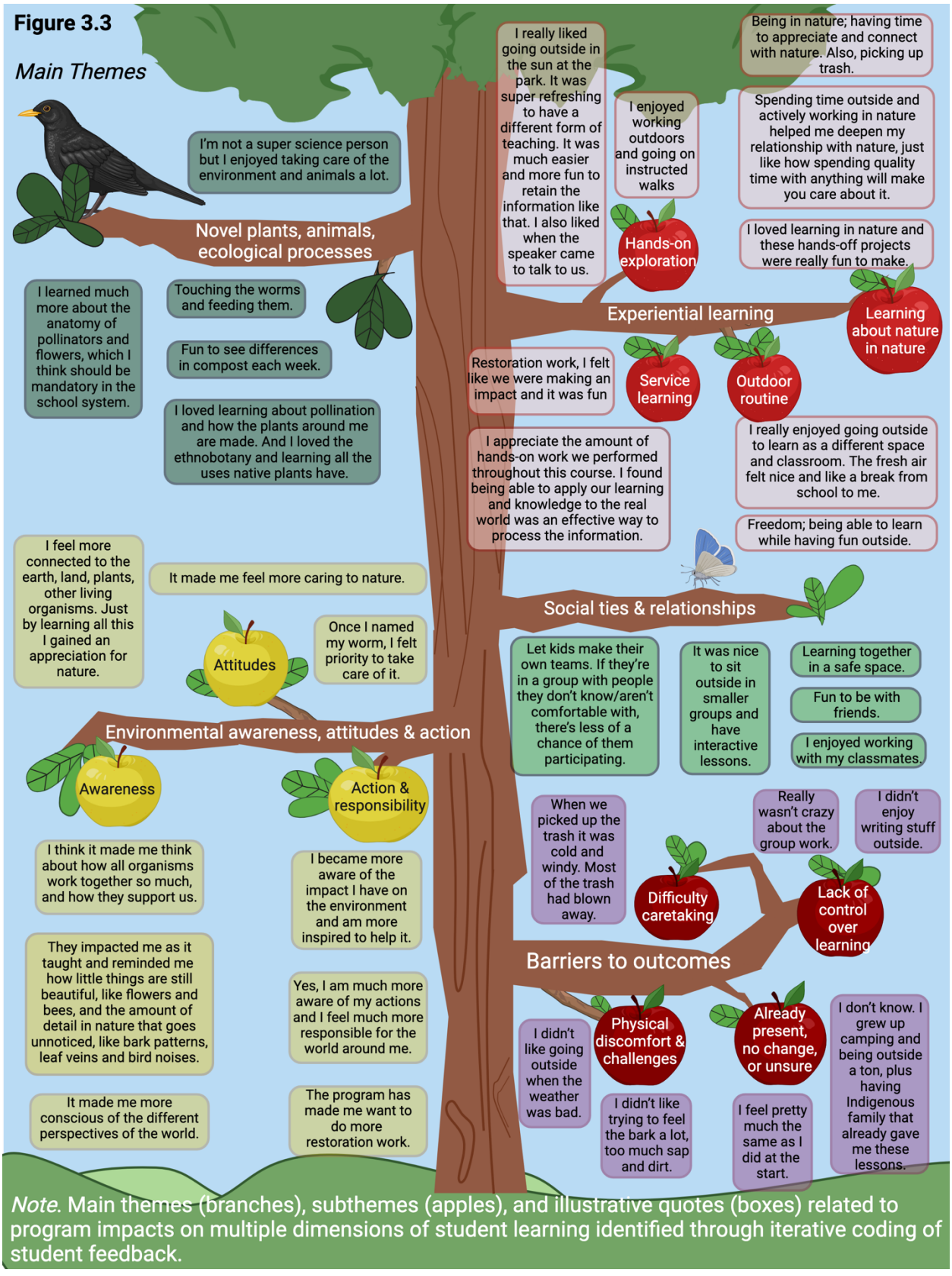
Despite the lack of significant quantitative changes in several dimensions, written and verbal feedback suggest that many students felt positively impacted by the program across the four dimensions. Experiential learning; using novel plants and animals; social ties and relationships; and environmental awareness, attitudes, and action emerged as key mediators of learning across dimensions; a fifth main theme emerged as barriers to outcomes (Figure 3.3).

Table 3.2. Mean pre- and post-program survey scores sorted by dimension, for students who participated in school-based braided environmental education in two curricular contexts.

Dimension		Emerging-1	Emerging-2	Mature-1	Emerging-3	Emerging-4	Mature-2
Environmental knowledge	pre	**2.00**	**2.80**	**3.13**	**2.52**	**3.26**	**3.55**
	post	**2.88**	**3.17**	**3.65**	**3.27**	**3.78**	**3.62**
	t, p	***t* = 5.3, *p* < 0.05**	***t* = 3.42, *p* < 0.05**	***t* = 4.09, *p* < 0.05**	***t* = 4.12, *p* < 0.05**	***t* = 5.14, *p* < 0.05**	***t* = -3.89, *p* < 0.05**
Environmental attitudes	pre	4.03	4.12	**4.15**	3.84	4.14	4.17
	post	4.06	4.20	**4.32**	3.73	4.24	4.35
	t, p	$t = 0.3, p = 0.75$	$t = 0.84, p = 0.40$	***t* = 2.93, *p* < 0.05**	$t = -1, p = 0.32$	$t = 1.34, p = 0.184$	$t = 0, p = 1$
Relationships with nature	pre	3.48	3.63	3.50	3.47	3.98	**3.99**
	post	3.54	3.84	3.74	3.40	3.99	**4.11**
	t, p	$t = 0.7, p = 0.48$	$t = 1.9, p = 0.06$	$t = 1.79, p = 0.08$	$t = -0.62, p = 0.54$	$t = 0.18, p = 0.86$	***t* = -2.50, *p*< 0.05**
Engagement with material	pre	3.22	3.36	**3.94**	3.34	3.86	**3.96**
	post	3.37	3.54	**4.05**	3.20	3.86	**3.83**
	t, p	$t = 1.29, p = 0.20$	$t = 1.59, p = 0.17$	***t* = 2.34, *p* < 0.05**	$t = -1.16, p = 0.25$	$t = 0, p = 1$	***t* = -3.62, *p* < 0.05**

Figure 3.3

Main Themes



Note. Main themes (branches), subthemes (apples), and illustrative quotes (boxes) related to program impacts on multiple dimensions of student learning identified through iterative coding of student feedback.

3.4 Discussion

The programs intended to teach students through braided education which is experiential, community-engaged, and land-based, and assess whether these interventions have influenced: students' engagement with material, environmental attitudes and knowledge, and relationship to nature. In this section, I explore the main themes (categories of similar codes) that facilitated learning, as identified through qualitative coding—experiential learning, novel plants and animals, social ties, and environmental awareness—alongside barriers to achieving desired outcomes. I triangulate these qualitative insights with the survey data and examine how program characteristics such as season, duration, and participant experience levels influenced score differences.

3.4.1 Main themes

Theme 1: Experiential learning facilitates learning across the four dimensions

Experiential learning was a cornerstone of the program, enriching students' environmental knowledge, attitudes, relationships with nature and engagement with material. Experiential learning enhanced knowledge through land-based learning involving scavenger hunts, tree and leaf assessments, bird observation and ID, restoration, pollination, and going on instructed walks. Simply being and learning outdoors was cited by several participants as a major factor that enhanced their learning as doing hands-on activities and learning outdoors versus in the classroom "helped the information stick" to "learn by experience instead of the teacher saying it" (Mature-1; Emerging-3). Students' experience of gaining knowledge through learning outdoors is supported by research that cites the positive relationship between green space and cognitive functioning (Vella-Brodrick & Gilowska, 2022). These same aspects of experiential learning that facilitated gaining knowledge facilitated engagement with material. The routine of being

outdoors during class time made learning more enjoyable and anticipated by students in several programs (Appendix 3.1).

Service-learning—a pedagogy that focuses on experiential learning through real-world applications, such as ecological restoration (Hansen & Sandberg, 2020)—positively impacted environmental attitudes. Having students conduct environmental caretaking (e.g., invasive species removal, managing compost, or exploring pollinator habitat restoration; Mature-1, -2; Emerging-3, -4) empowered them with know-how which led to deeper feelings of care, concern, and action competence. Being able to make a difference was a key response from students in the Mature contexts where ecological restoration was a significant portion of the year-long curriculum. Being able to see a starting point and end point with removal of invasive species in a patch they kept returning to as a cohort was key. Conducting caretaking with service-learning also enhanced engagement with material, as students reported the restoration aspects and taking care of worms to be fun and enjoyable (Mature-1; Emerging-3).

Based on the qualitative feedback, "learning about nature in nature" also enhanced relationships with nature for students in programs with a high proportion of outdoor lessons (Emerging-1, Emerging-2, Mature-1, Emerging-4, Mature-2). Spending time outside and working in nature helped to deepen those relationships, as students mentioned the role of quality time as an important ingredient for cultivating relationships, aligning with discourse mentioned by Charles & Cajete (2020) and Diver (2019) that emphasize the importance of time spent on the land to cultivate reciprocal relationships with the land.

Learning about how humans are dependent on the service of plants and animals impacted students' relationship with nature, making them feel more connected to earth, land, plants, and other living organisms. This learning coupled with service-based activities (invasive species

removal, stewarding worms, picking up trash) worked as conduits for deeper nature connection. Engaging directly with the environment fostered sensory-rich experiences that also deepened their relationships with nature. Hands-on activities like building compost bins, touching bark, smelling worms, or looking at soil fauna under the microscope were memorable experiences that students recalled helping them learn, demonstrating the importance of sensory-rich experiences in anchoring learning for environmental education or as a "pathway" to nature connectedness (Beery & Jørgensen, 2018; Lumber et al., 2017; Richardson et al., 2020).

Theme 2: Novel plants and animals positively impact the four dimensions

Interaction with novel plants and animals proved to be a powerful tool for engaging students across all dimensions. Although working with plants and animals is inherently tied to experiential learning, novel plants and animals emerged as a main theme given students consistent reports in how engaging with plants and animals enriched their understanding, connection with the material, connection with each other, and connection with the natural world. Working with birds, worms, soil fauna, insects and other pollinators, finding animals in the park or working with local plants helped to increase knowledge and engagement of students, and was a major pathway for youth to connect with nature (Emerging-1, Mature-1, Emerging-2, Mature-2, Emerging-3, Emerging-4). Some students describe how after participating in the program they "treat plants as if they're an old friend instead of just a random plant", while others describe how once they named their worm, they felt more of a priority to take care of it (Mature-1; Emerging-3). Especially when these instances were novel such as seeing soil fauna under the microscope or finding unusually large mushrooms and pinecones, it created the starting points for place-based relationships, where students would return to these aspects upon return visits or future sessions. A key collaborator in the Emerging context mentioned that having these experiences as

something different than they would normally experience in their classroom was key for facilitating engagement. As awe and interest in nature are pathways to facilitating nature connection and protection (Neurohr et al., 2024; Ng et al., 2023), including topics and activities that stimulate interest in students are promising practices for EE programs.

Animals seemed to provide a focus in which attitudes like care, respect, appreciation, and awareness could be applied. Students wrote that they enjoyed taking care of animals despite not being a "super science person". Animals work well to activate the emotional dimensions of the learner and deepen relationships to the natural world as emotions are a pathway to nature connectedness (MacPhereson, 2011; Richardson et al., 2020). In critical paradigms, more-than-human beings are an effective way to cultivate meaningful relationships with other aspects of creation, such as plants or birds as seen in our study and others (e.g., Carvalho et al., 2020; Shin et al., 2024; Taylor et al., 2015). Plants too had a positive impact, specifically invoking gratitude and appreciation in learners especially where ethnobotany was a main topic (Mature-1; Emerging-1), in line with research that shows how plants are important tools in EE (Tsevreni et al., 2021).

Theme 3: Social ties as supports and outlets for learning and sharing

Social interactions with family, friends, and teachers played a crucial role in reinforcing learning and engagement. Sharing experiences with family and neighbours helped to solidify knowledge and facilitate actions toward restoration or conservation for students in several programs especially where service-learning or project-based learning was applied (Mature-1; Mature-2; Emerging-3; Emerging-4). For instance, students from the Mature context who participated in restoration were able to identify noxious species in their neighbours' hard and advise their removal. Students who worked closely with worms and pollinators (Emerging-3, Emerging-4)

similarly were able to prevent their neighbours or family from eradicating helpful insects and explained their importance in composting and pollination, or even started their own composting at home.

In all programs, students noted that the program sessions were more enjoyable when being able to connect with friends and make their own groups. Positive relationships *with* nature were cultivated through creating positive experiences *in* nature through being outdoors with friends, taking walks in groups, looking for plants and animals together, doing journaling, or simply being. Students in Emerging-3, Emerging-4 reported learning together was helpful for solidifying knowledge. Whether through creating a safe learning community or having post-lesson closing circles, students felt safe to ask questions and could also hear what other students learned in sharing circles. They found it interesting, able to connect more to their peers, and also helped their learning sink in.

Participating in scavenger hunts and other games with friends helped students engage with material in Emerging-1, Emerging-2, Emerging-3 and Mature-1. Stern et al. (2014) cites play-based learning as an important environmental education pedagogy, while Ardoin et al. (2018) identified play as a mediator of learning for early childhood education. Student feedback suggests that play in EE is also important for older cohorts, supported by teacher collaborators in both contexts who used fun and enjoyment of students as barometers for program success. However, it is worth noting that a participant in Emerging-2 noted how the absence of socializing and friends also facilitated her own strong interest and connection with nature. She described how socializing can be a distraction and can take priority over engaging with lessons and activities, and her own connection with nature flourished when she had solitary moments on the land. Thus, embedding both social time and solitary time might be beneficial for programs so

students can have the fun social experiences but also time for personal learning and reflection. Balancing solitary reflection and communal learning reflect Indigenous principles of learning as outlined by Cajete (2010). Social ties and relationships had positive impacts on the educators as well. Consistent feedback from collaborators in both curricular contexts note the importance of walks to and from the park/nature sanctuary in being able to get to know students in ways that classroom learning does not offer. These relational benefits align with the relational focus of Indigenous environmental education which works to strengthen relationships with self, the land, and community (Nesterova et al., 2020).

Theme 4: Environmental awareness and attitudinal shifts

Despite the lack of significant statistical improvement in environmental attitudes in most programs, qualitative feedback from students suggests that participating in programs had a meaningful influence on their environmental awareness and attitudes. Students in Emerging-2, -3, -4 and Mature-1 mentioned that a main outcome was that programs increased their environmental awareness. In many cases, awareness was linked to expanded understanding—such as an awareness of plants and their roles, interconnections and respecting those interconnections, awareness of the positive and negative impact of human actions, awareness of the role of smaller insects (composting, pollination), and how "everything matters and accumulates". In some instances, this awareness was linked to behaviours such as picking up trash, removing invasive species, or making efforts to compost. In other instances, awareness was linked to feelings of concern and wanting to help or protect it. Awareness was also linked to students being more aware of different perspectives or looking at the world in different ways, introducing students to ideas and perspectives they would not have otherwise thought of, or being more aware of details in the environment (Appendix 3.1).

Based on the qualitative data, environmental attitudes that these programs helped to cultivate or reinforce include appreciation, awareness, responsibility, and care, often driven by mechanisms involving knowledge and skills related to learning about plants and animals or conducting caretaking (Figure 3.3, Table 3.3). Students often mentioned how increased knowledge leads to increased feelings of care, which lead to a shift in action (Mature-1, -2; Emerging-3, -4). Across several programs (Emerging-2, -3; Mature-1; Appendix 3.1), students found that learning about nature opened an appreciation or deepened a pre-existing appreciation, for nature: "…I always felt this way, but now I really know about it" (Mature-1).

Table 3.3. Illustrative quotes supporting shifts in environmental attitudes from programs in which significant attitudinal shifts were not detected with surveys.	**Program**
Made me appreciate how beautiful nature is	Emerging-1
It's a responsibility to take care of the environment, to not only influence yourself but all of those around you and to keep the world a beautiful place	Emerging-2
Yes my perspective on bugs and nature have changed and now I want to help them much more. Learning about these topics really impacted me	Emerging-3
I feel more responsibility because I've learned how much nature provides us	Mature-2
Yes I think about protecting bees and our pollinators more and I want to do something about it	Emerging-4

Kimmerer (2012, 2013, 2017) discusses the transformative power of content- and process-based knowledge shifting relationships toward gratitude and appreciation, particularly through the respectful integration of Indigenous and Western Science perspectives. This framework, which emphasizes reciprocity, gratitude, and a holistic understanding of the natural world, presents students with a worldview that encourages ongoing reflection on their relationship with the land. *Braiding Sweetgrass*'s persistent messaging about the gift economy—the idea that nature gives to us, and we have a responsibility to give back—helped students in Mature-1 cultivate a deeper sense of appreciation and responsibility toward the environment. The

repeated exposure to this theme throughout the text in conjunction with outdoor learning/conducting hands-on restoration may have allowed students to internalize this ethic of reciprocity, resulting in significant, quantifiable shifts in their environmental attitudes (Table 3.1). Reflective nature journaling conducted by students in Mature-1 likely also influenced their environmental attitudes, consistent with other studies in EE such as Tsevreni et al. (2021) and Warkentin et al. (2011).

However, I observed that all programs contained students that reported positive shifts in attitudes, often facilitated through learning which led to a deeper understanding and connection, stimulating the desire or intention to learn or do more about it (Emerging-1, -2; -4; Mature-1, -2) (Table 3.3). Though there were a lack of statistically significant results in the quantitative data, quantitative trends combined with qualitative methods emphasized that the programs allowed students to appreciate nature's beauty, notice details that often go unnoticed, and generally expanded or deepened appreciation for plants and their abilities (Table 3.1, Table 3.3).

Action competence and responsibility emerged as key findings in programs that involved service-learning and project-based learning (Mature-1, Mature-2, Emerging-3, Emerging-4). Students mentioned that knowledge was a key facilitator in environmental action, such as providing know-how to steward the land, or just feeling more responsible for helping given what they know now. Conducting environmental caretaking, such as restoration, made students feel responsible, and grateful, for taking action to restore the landscape that they appreciate.

Theme 5: Barriers to outcomes

Several barriers to achieving program outcomes were identified in the qualitative data, including physical discomfort, curricular challenges, and a lack of control over learning processes. Addressing these barriers is essential for enhancing the program's impact. Several barriers to

learning emerged. The most cited reason fell under the subtheme of physical discomfort, often involving the dislike of walking or hiking up hills; being in inclement weather (too wet, windy, cold, or warm); allergies; being indoors; certain tactile sensations (e.g., sap from trees); physical exertion (e.g., restoration and pulling invasive plants); and insects (mosquitos, caterpillars). In another study of impacts of outdoor EE programming, Talebpour et al. (2020) found that inclement weather was related to a poorer connection to nature.

Another aspect of programming that posed barriers to student learning involved curricular topics or activities—dislike of certain activities, not being well explained, or being too repetitive, or finding them uninteresting. A third barrier to outcomes was lack of control over learning, such as being unable to make their own groups which led to decreased participation and engagement. Having situations that did not facilitate caretaking (e.g., lack of trash to pick up), English not being a first language, and curricular constraints around time for each topic were also student responses as to why there were barriers to learning.

At least five students in each program reported that the program did not impact them in certain dimensions or reported no change. A common reason for lack of program impacts was that knowledge, attitudes, relationships with nature, or engagement with material were already present. Several students mentioned how they have grown up being in, and appreciating, the outdoors such that caretaking and responsibility were natural for them and those attitudes are already present or having Indigenous relatives that were able to impart knowledge and wisdom. A growing body of literature cites diversity and frequency of childhood nature experiences as being related to pro-biodiversity or pro-environmental attitudes and behaviours later in life (Aota & Soga, 2023; Cleary et al., 2020). Thus, these previously existing levels could offset the lack of change in dimensions in several programs.

3.4.2 Impact of program characteristics

Duration of programs (10-month, 3-months)[3] and season when programs were conducted (Fall, Spring, All-year) have statistically significant effects on how the scores changed from pre-test to post-test. Based on the results, Fall shows the highest positive impact on changes from pre- to post-program scores compared to both Spring and All Year programs, and Spring programs had the least impact on scores. This finding could be due to students in Fall being more receptive to learning or having more energy after coming back from summer break, more favourable conditions for outdoor learning, the characteristics of these particular cohorts, or the particular topics studied/activities conducted. In terms of duration/context, shorter-duration/Emerging context programs have larger gains from pre- to post-program. The lesser improvement in longer-duration programs could be due to the higher base-line knowledge, attitudes, and relationships with nature of students in the Mature-context where the longer-duration programs were held. This suggests that while participants in Mature programs may have higher initial knowledge or skills, the program's impact on enhancing those skills (as measured by score changes) might be less pronounced compared to Emerging programs. Additionally, despite the attempt to equalize teaching efforts across contexts in terms of number of program sessions and amount of content delivered, the shorter-duration programs had a more streamlined curriculum and may have been a more concentrated experience compared to a the longer-duration programs where learning objectives were more spaced out, leading to a slower accumulation of knowledge and skills.

[3] Program duration (3-month, 10-month) and context (Emerging, Mature), represent the same thing mathematically. For the purposes of my discussion, they will be considered as a unit, “duration/context”, since these variables cannot be pulled apart to make claims for one or the other as being the key driver of changes observed.

3.4 Caveats & Considerations

While the findings from this study provide valuable insights into the impact of our educational programs, several caveats and considerations must be acknowledged to better understand the context and implications of the results. The interpretation of scores, the process of data triangulation, and the role of process evaluation are crucial factors that merit further discussion. Pre-to-post survey analysis revealed gains in environmental knowledge, attitudes, relationships with nature, and engagement with the material, with only the knowledge dimensions (and attitudes in Mature-1) reporting a statistically significant increase in all programs, and some decreases in Emerging-3 and Mature-2. Although the absolute increases were modest (ranging from 0.1 to 0.8 on a 5-point scale), these changes are consistent with findings from similar EE programs (Baieri et al., 2022; Bergman, 2016; Hamilton & Marckini-Polk, 2023; Pirchio et al., 2021). Small gains suggest meaningful progress, particularly in the context of short-term educational interventions or in environmental attitudes and relationships with nature in which changes are typically gradual. Even a small shift in attitudes can lead to a radically different way of looking at the world (Kimmerer, 2013).

Explaining gains in knowledge and mostly non-significant gains in attitudes, relationships with nature, or engagement with material could be due to several reasons. One is fast-and slow-learning, where knowledge is in line with relatively faster-learning, as knowledge can be easier to access and increase in the short-term with education interventions and is more sensitive to measurement through immediate assessments. Attitudes and relationships are more complex and involve personal changes that develop over longer periods of time. Initial exposure might spark interest or awareness, but significant changes in attitudes and relationships with nature might take more time and repeated engagement (Diver et al., 2019). As environmental educator Richard Kool suggests, “The real things, the ways in which environmental education

can change someone's life, are much more subtle and difficult to measure." (as cited in Thomson et al., 2010, p. 33). Also, high-baseline attitudes leave less room for measurable improvement.

Consistent with braided education, having multiple lines of evidence helped interpret the findings from different perspectives (Kimmerer, 2012). For instance, while the survey results show a decrease in several dimensions from pre-to-post for Emerging-3, in the post-program interview, the main collaborator in the Emerging context had shared that Emerging-3 seemed the most successful of the Emerging programs from their perspective, consistent with student focus group feedback responses that described how most students found the composting program engaging and interesting, and had impacts on their environmental awareness regarding managing food waste and new appreciation for the small insects that drive decomposition processes.

Although surveys offer benefits by being able to detect general patterns at a higher-level of organization at the classroom or cohort level, surveys may not be the best evaluation tool for school-based programs that braid Indigenous and Western Science. Surveys are not considered culturally responsive mode of Indigenous program evaluation given the focus on reading and writing (in English in this case) and using two-time points to capture the entire process of learning, as opposed to sharing circles which can be conducted throughout the program process or focus groups which allow participants to provide richer context (Brown & Di Lallo, 2020; Hudson et al., 2017). For instance, when focus groups were conducted in this study, students reported that although responsibility was not necessarily enhanced, they noted how their environmental awareness was increased and made them more mindful moving forward, which led to a discussion of certain actions they have already taken or plan on taking to put their knowledge and experiences into use. Surveys may also not be the best fit for programs developed and evaluated with developmental evaluation approaches, such as these, where program

decisions involving content and pedagogies can unfold over time based on context-specific variables such as participants, collaborators, or environmental factors. Such an adaptive nature of programming poses a challenge to the rigidity of survey items set in the pre-program surveys. Therefore, while surveys can be useful for larger-scale programs focused on assessing specific variables across multiple sites or understanding logistical factors like timing and duration, they may add less value when the goal is to capture the nuances of participant experiences, especially when a culturally responsive evaluation approach is desired.

3.5 Conclusion

Environmental education programs that braid Indigenous and Western Science perspectives and incorporate experiential learning, novel plants and animals, and social ties have shown considerable promise. This study evaluated six such programs in Emerging and Mature curricular contexts using multiple methods, assessing their impact on environmental knowledge, attitudes, relationships with nature, and engagement with material. While surveys revealed immediate knowledge gains, changes in attitudes, relationships, and engagement were better captured through qualitative feedback. These findings underscore the importance of prioritizing qualitative and adaptive approaches as culturally responsive evaluation tools and highlight how braided programs can deepen relationships with nature, enhance environmental awareness and attitudes, and cultivate knowledge and engagement with material. Although school-based programming shows promise for fostering long-term environmental stewardship, ongoing efforts are necessary to secure enduring benefits.

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3.7 Appendices

Appendix 3.1 Participant feedback sorted into main themes and subtheme.

Theme	Subtheme	Illustrative responses	Program
Experiential learning	Land-based / hands-on exploration	Freedom; being able to learn while having fun outside. Enjoyed looking for birds. Liked finding different trees at the park, though it was a bit difficult	Emerging-2
		For me, I liked going outside, doing the scavenger hunts, and just chilling outside	Emerging-2
		The more hands on approach; scavenger hunts.	Emerging-2
		Finding plant species and tree species	Emerging-2
		Looking for birds and flowers	Emerging-2
		Going through the easy activities like when we would sit outside and journal or just look around for things	Emerging-2
		Being outside in the sun	Emerging-2
		I enjoyed working outdoors and going on instructed walks	Mature-1
		I liked doing stuff outside	Mature-1
		I enjoyed the plants scavenger hunts	Mature-1
		Hands on stuff, experiential	Emerging-3
		Walking to park	Emerging-3
		Experience it versus teacher telling it	Emerging-3
		Doing hands on is good to stay engaged versus just listening	Emerging-3
		Way it was taught was more engaging	Emerging-3
		I like more the manual stuff. In English is hard to learn by talking so I prefer to touch worms better than write.	Emerging-3
		The break from the classroom setting, and how we had a lot of freedom as to how we conducted the research	Emerging-4
		Spending time outside, watching pollinators, learning about them, learning how to catch and photograph them for our project	Emerging-4
		I enjoyed the project, very self directed	Emerging-4
		I really liked going outside in the sun at the park. It was super refreshing to have a different form of teaching. It was much easier and more fun to retain the information like that. I also liked when the speaker came to talk to us.	Emerging-4

	Excellent delivery of information and use of collaboration in teaching; learning how pollination works; ability to reflect on learning frequently, slow approach to learning, no need for homework; lots of resources provided for the project	Emerging-4
	Hands on learning outside of the classroom	Emerging-4
	Getting to walk around the nature sanctuary on scavenger hunts	Emerging-4
Learning about nature in naure	I really enjoyed the outside days when we were matching the flash cards to the types of plants	Emerging-1
	Learning outdoors versus in the classroom (better outdoors)	Emerging-2
	Most activities, like birds, tree, leaf identification, pollination scavenger hunt, measuring trees. I looked forward to every activity and they were all enjoyable in one way or another. Meeting many cool dogs, being close to the ocean, exploring habitats, the given freedom.	Emerging-2
	Being in nature; having time to appreciate and connect with nature. Also, picking up trash	Emerging-2
	Positive, because I got to learn more about it	Emerging-2
	Yes, it expanded my knowledge about nature	Emerging-2
	I got to learn about plant species and birds and trees	Emerging-2
	That how leaf species work and what there called and I'm happy that I got to learn about nature and leafs	Emerging-2
	One of my favourite topics we learnt about was pollination because I felt the way we did all the learning really helped the information stick	Mature-1
	Get to enjoy nature more often	Mature-1
	I enjoyed learning about the different plants and their uses and also looking for them around the lake on walks	Mature-1
	I enjoyed the hands-on learning aspects like when we had a short lesson on pollination outside and then explored and took pictures in the big pollinator garden	Mature-1
	The most enjoyable aspects of the environmental science was learning about pollinators and their bonds and doing restoration work and learning about what plants to pull out	Mature-1
	I enjoy learning and being outside	Mature-1

	I don't think I was impacted other than the knowledge I gained from participating in the program	Mature-1
	I am now able to identify plants and their uses, and names (obviously) when on a walk	Mature-1
	Spending time outside and actively working in nature help me deepen my relationship with nature, just like how spending quality time with anything will make you care about it.	Mature-1
	Sitting by the lake	Mature-1
	connecting with Nature	Mature-1
	The games to test my knowledge and learning outside	Emerging-3
	Free research on pollinator plants	Emerging-4
	Being out in nature and learning all about the nature that we were in	Emerging-4
	Going outside and observing the pollinators	Emerging-4
	Going outside and chilling with the bees	Emerging-4
	I loved learning in nature and these hands-off projects were really fun to make	Emerging-4
	I liked going outside as part of the program. It definitely think it helped my learning when it comes to pollinators and their habitat restoration	Emerging-4
	Yes it really improved my knowledge of pollinators. I learned a lot	Emerging-4
	Knowledge yes. I learned the things you taught about pollination	Emerging-4
	Learning about nature and learning in nature was really interesting, much more than a classroom	Emerging-4
	I liked bird watching. I enjoy just observing things	Mature-2
	Spending time in nature	Mature-2
	The wading was definitely my favourite day	Mature-2
	Learning about soil and taking samples from the land	Mature-2
	Restoration and learning about the plants, animals, habitats and niches	Mature-2
Service-learning	I personally enjoyed the restoration, although not really a lesson I just love that is different from most classes	Mature-1
	Hands on restoration	Mature-1
	Going to the nature sanctuary and doing restoration	Mature-1

	Clipping invasive species	Mature-1
	Restoring the area	Mature-1
	Restoration; I loved climbing up the hill	Mature-1
	I loved the restoration we did and I liked the pollination lessons. They were both really informative and I'd suggest that everyone should try the restoration work	Mature-1
	Yes, I never knew there were so many invasive species that were impacting our land, which is why I like doing restoration.	Mature-1
	I just learned about how many invasive species really inhabit the island! I would be interested in doing more restoration work in the future	Mature-1
	Building mini-composts	Emerging-3
	The research project, creating the plan for a garden, and working together	Emerging-4
	I appreciate the amount of hands-on work we performed throughout this course. I found being able to apply our learning and knowledge to the real world was an effective way to process the information	Emerging-4
	The restoration part	Mature-2
	I really enjoyed working on our adopt a patch because I like the feeling of helping out nature	Mature-2
	Restoration work, I felt like we were making an impact and it was fun	Mature-2
	Doing restoration and generally just being at the nature sanctuary	Mature-2
	I liked restoration and looking at animals	Mature-2
	Learning how and doing the restoration work	Mature-2
	Restoration was a really good time	Mature-2
	Restoration and being able to learn outside	Mature-2
	The program that I took over the coruse of two years taught me so much from restoration skills and general knowledge. I am way more capable of identifying native plants and invasive plants	Mature-2
	A bit yes, with how big of a difference our restoration work made,	Mature-2
	I now have things I know I can do to help not just useless worry	Mature-2
	Regularity of coming on Thursdays	Emerging-2

	Environmental education routine	Walking around every Thursday instead of doing science	Emerging-2
		Going outside instead of the classroom to learn	Emerging-2
		Going out of the classroom	Emerging-2
		I liked getting to be outside during the school day	Mature-1
		I really enjoyed being able to get out of the classroom and being able to be outside and get to the nature sanctuary a little more	Mature-1
		It gave me a great opportunity to be in nature during school	Mature-1
		Different than what we're used to	Emerging-3
		When we went to the park	Emerging-4
		I really liked the ability to go to the park, somewhere outside school, to learn and do work	Emerging-4
		Just being able to get outside of the classroom and learn outdoors	Mature-2
		Being able to leave the classroom and have fun	Mature-2
		I really enjoyed going outside to learn as a different space and classroom. The fresh air felt nice and like a break from school to me	Mature-2
Novel plants and animals		Big mushroom	Emerging-1
		Franny the dog	Emerging-1
		It was a positive influence because I got to see what plants people were talking about in person and I can now recognize them	Emerging-2
		I now recognize how many species of plants we have in our area, and how many purposes they have to assist us and our environment	Emerging-2
		Learning about plant diversity, pollination, and how plants were used as medicine	Emerging-2
		Large pinecone	Emerging-2
		Giant mushroom	Emerging-2
		I really enjoyed learning about pollination	Mature-1
		I particularly enjoyed learning about ethnobotany and how plants and animals connect to each other	Mature-1
		I loved learning about pollination and how the plants around me are made. and I loved the ethnobotany and learning all the uses native plants have	Mature-1
		I'm not a super science person but I enjoyed taking care of the environment and animals a lot	Mature-1

		I liked learning about the native plants in our area, and the uses of then	Mature-1
		It was really cool to learn about how different pollinators have “matches”	Mature-1
		I feel it probably it probably did, I find myself treating plants as if they’re an old friend, instead of just this random plant	Mature-1
		Fun to see differences in compost each week	Emerging-3
		Looking at soil fauna under the microscope	Emerging-3
		I really liked learning about the worms	Emerging-3
		I enjoyed learning about the ingredients and layering	Emerging-3
		I really liked seeing the compost bins deconstruct all the food scraps	Emerging-3
		Touching the worms and feeding them	Emerging-3
		Taking care of the worms was fun	Emerging-3
		Seeing the worms	Emerging-3
		I learned much more about the anatomy of pollinators and flowers, which I think should be mandatory in the school system	Emerging-4
		Getting into nature, restoration, looking at the soil fauna	Mature-2
		Learning about native plants	Mature-2
		When we went down to the water and looked at all the bugs	Mature-2
		Yes, actually seeing plants outside	Mature-2
Social ties and relationships		Being stuck on rock	Emerging-2
		It was nice to sit outside in smaller groups and have interactive lessons	Mature-1
		Learning together; safe space	Emerging-3
		Group work and being able to pick groups	Emerging-3
		Fun to be with friends	Emerging-3
		I enjoyed working with my class mates	Emerging-3
		Let kids make their own teams. If theyre in a group with people they don’t know/aren’t comfortable with theyres less of a chance of them participating.	Emerging-3
Environmental awareness and attitudes influenced by knowledge	Awareness	They impacted me as it taught and reminded me how little things are still beautiful, like flowers and bees, and the amount of detail in nature that goes unnoticed, like bark patterns, leaf veins and bird noises	Emerging-2

I think it made me think about how all organisms work together so much, and how they support us	Emerging-2
It made me more aware of nature	Emerging-2
Kinda because now I know more stuff	Emerging-2
I realized how many pieces of little trash there was. I feel like little pieces could hurt animals more because it is easier to eat. These lessons made me more aware of little things like that	Emerging-2
Yes, it made me more aware that everything we do affects nature	Emerging-2
I was impacted by how much garbage you can find when you look closely	Emerging-2
That how leaf species work and what there called and I'm happy that I got to learn about nature and leafs	Emerging-2
Yes I feel more aware of little things in the environment I didn't think about before. I'm more likely to pick up trash or things like that	Emerging-2
I was impacted by how much garbage you can find when you look closely	Emerging-2
I think I learned a lot more valuable information about our natural world	Mature-1
They gave me a better understanding of plants. Plants have such more use than I thought they did until last year. The lessons and experiences taught me a lot	Mature-1
I would say so, yes. I now know a lot more about pollination, ethnobotany, Indigenous views, and how to properly do restoration work	Mature-1
Yes I now feel I care more for the environment and have been impacted by braiding sweetgrass	Mature-1
They showed me that humans, plants, and animals are more connected than I realized and that the connection should be honoured and respected	Mature-1
Honestly I think I always felt this way, but now I really know about it.	Mature-1
Yes being more careful when I walking and making sure I dont walk on them	Mature-1
Yes they did they made me more aware of how I was treating the earth and how I can better take care of it. (	Mature-1
Yes, I am more careful	Mature-1
The program promotes environmental awareness and concern	Mature-1

Yes it made me look at the world different.	Mature-1
I think I became more aware of my impact on the environment and have tried to make more of an effort to protect it.	Mature-1
Yes they did make me think more about my relationship with the Earth	Mature-1
Through these lessons I better understand my impact on the environment	Mature-1
They impacted how I think about my impact on the environment in a positive way	Mature-1
They definitely impacted me. I'm much more aware of my own actions when it comes to the environment	Mature-1
Yes probably thinking more mindfully of things around me	Mature-1
It made me more conscious of the different perspectives of the world	Mature-1
The lessons and experiences all taught me new and different things that I otherwise wouldn't know	Mature-1
Thought about composting more outside of school	Emerging-3
Perspectives around smaller insects—everything matters; everything adds up	Emerging-3
Worms are more useful than I thought they were	Emerging-3
I always think that the compost is important, but this helped me to understand it more	Emerging-3
Yes, I learned more about what really goes on when composting. This unit helped me understand more about the good effects of composting	Emerging-3
Yes because I know what happens to my waste once I throw it in the trash	Emerging-3
Yes because now I truly know how important pollinators are	Emerging-4
I am more conscious of pollinators and the very important role the play in our ecosystem	Emerging-4
I definitely learned more about different kinds of gardens (cultivated and native) which led to more awareness I think on how important it is to actively support plants for pollinators	Emerging-4
Yes I learnt a lot, I learned that there are many types of pollinators than I thought	Emerging-4

	Throughout the program I gained new knowledge pertaining to the preservation of nature and environment. I was able to acquire new understandings of different perspectives	Emerging-4
	Yes because now I know how much of an impact I can have	Emerging-4
	I don't feel more connected to nature after this program, but I do think I've gained some skills and knowledge which will allow me to tread ore lightly on the land and make a difference	Emerging-4
	I think that I will be more aware of what I am doing around my house, such as upkeeping the mason bee and butterfly hives, and increasing the variability in my gardens	Emerging-4
	I think it made me more aware of how much effect we have	Mature-2
	It made me realise the environment is more important than I thought	Mature-2
	I became more aware of environmental issues in general	Mature-2
	Yes, it gave me a better knowledge of how even the smallest things are a big part of an ecosystem	Mature-2
	It made me think more about which actions that we take all actions we take effects the earth in positive and negative ways	Mature-2
	I feel more in touch with nature as I feel I know more about nature	Mature-2
	It influenced me by noticing and wanting to get rid of invasive species and beign more aware of native plants and how important they are	Mature-2
Responsibility & Action	It's a responsibility to take care of the environment, to not only influence yourself but all of those around you and to keep the world a beautiful place	Emerging-2
	It made me want to pick up trash I find that was close to a trash can	Emerging-2
	Yes. I was able to identify daphne in the property behind my house, warn neighbours (with small children and dogs) of them and have them removed! And lead to my grandma identifying it and removing it from her backyard.	Mature-1
	I became more aware of the impact I have on the environment and am more inspired to help it	Mature-1
	Yes, it made me want to restore my cabin's forest	Mature-1

I feel like I have more knowledge of how to restore and take care of the Land.	Mature-1
The program has made me want to do more restoration work	Mature-1
Yes it did I learned to appreciate Indigenous plants and how to get rid of invasives	Mature-1
It did a little by teaching me what I can do to help	Mature-1
I feel more responsible for the environment now	Mature-1
Yes, I am much more aware of my actions and I feel much more responsible for the world around me	Mature-1
Yes doing restoration made me more responsible	Mature-1
It has prepared me to take care of nature that I appreciate so much	Mature-1
Definitely. I will definitely have a garden when I grow up.	Mature-1
I think it impacted a little—the more you know the more you care and can relate to them and the more careful you are (not mix stuff up with waste management)	Emerging-3
Manage scraps more mindfully	Emerging-3
rather than throw an apple core in the garbage, would pocket it and compost it at home	Emerging-3
Started a compost	Emerging-3
Yes because I now know how to take care of worms	Emerging-3
Instead of throwing food scraps out I feed them to my neighbour's geese (only if the food is safe and I have consent from my neighbours to feed his geese	Emerging-3
It influenced my thoughts on composting and I might even try it myself	Emerging-3
It made me question the people in charge of our green areas and parks even more cause why are we still using mono-culture grass instead of moss or clover or literally anything else	Emerging-4
Yes my perspective on bugs and nature have changed and now I want to help them much more. Learning about these topics really impacted me	Emerging-4
I know somewhat more about pollinators, behaviours, and needs; I have a better understanding of the importance of pollinators and humans impact on them; I feel more	Emerging-4

	motivated now to learn how I can make an impact to protect pollinators and pollinator habitats	
	The in formation I learned will definitely impact what I choose to plant in my garden when I do next, as the knowledge I gained is very specific to what our gardens should contain to be more pollinator friendly	Emerging-4
	Yes I think about protecting bees and our pollinators more and I want to do something about it	Emerging-4
	I think it did, seeing as the very next day when I was looking for new plants I specifically chose pollinator friendly plants	Emerging-4
	Yes I want to protect and save nature as well as the pollinators	Emerging-4
	I believe that this program helped me in this way by providing me with attainable methods to do my part in the preservation of our environment, further forming my pre-existing feelings of responsibility	Emerging-4
	I think I changed for the better because I know more about nature and how to care for it	Mature-2
	It made me want to do more restoration	Mature-2
	I feel more responsibility because I've learned how much nature provides us	Mature-2
	Yes by learning more about these things I now know more ways I could take care of it	Mature-2
	It made me feel that we have a responsibility to protect nature	Mature-2
	It has and I have actually restoration outside of school and just in every day life	Mature-2
	I do feel more capable of helping	Mature-2
	restoration has influenced me a lot in terms of wanting to make a difference	Mature-2
	The program taught me how to acknowledge the land and overall feel more grateful towards what we have	Mature-2
Attitudes	Made me appreciate how beautiful nature is	Emerging-1
	The most enjoyable part was probably pollination because of the face that I have a deep appreciation for the natural world, so learning more about these elements is always entertaining	Mature-1

especially pollination because of how important that is to the functions of our planet	
Yes the experiences have impacted me in a few ways. For example, just having the ability to learn in nature on a weekly basis is freeing and provides a nice and necessary break from basic classrooms. The lessons have done well in showing how well ecosystems coexist and has expanded my appreciation for plants and their abilities	Mature-1
I feel more connected to the earth, land, plants, other living organisms. Just by learning all this I gained an appreciation for nature	Mature-1
They gave me a deeper appreciation of nature	Mature-1
It impacted me a bit by making me care a bit more about the environment	Mature-1
Yes I feel like I understand nature better. I can connect with it more in a way. My viewpoint is now more caring/responsible for nature and its ecosystems.	Mature-1
The program taught me lots and I feel that I now appreciate it more	Mature-1
Definitely. They did further impress on me the need to care for nature.	Emerging-3
It made me more thankful for the Land I'm on.	
I have found new appreciation for the patches of land we took care of and am proud of how much we changed it	Emerging-3
It made me feel more caring to nature	Emerging-3
Yes they did. I am not afraid of compost now	Emerging-3
Once I named my worm I felt priority to take care of it	Emerging-3
I feel that nature is very important to all human life	Emerging-3
I definitely learned a lot and feel more conscious about the situations. I learned about the different species and their anatomies, and feel a lot stronger about the importance of keeping them safe	Emerging-4
Kind of, I learned that we need to protect native species of pollinators	Mature-2
It only enforced and elevated my concern and compassion for nature	Mature-2
A little. I definitely have more respect for them now	Mature-2

		I am more appreciative of the natural world around us from our many learning activities	Mature-2
		It deepened my already strong connection to nature	Mature-2
		Yes, it really made me feel good when I helped out nature	Mature-2
		It gave me a greater appreciation of the natural world	Mature-2
Barriers to outcomes	Physical discomfort	The heat	Emerging-2
		I didn't like going outside when the weather was bad	Emerging-2
		Pollinator garden; do not like flying insects	Emerging-2
		When I got a headache from the heat	Emerging-2
		I didn't like trying to feel the bark a lot, too much sap and dirt	Emerging-2
		I have allergies. Every time we went outside my nose would get stuffy and my eyes would water which would make it difficult to focus, and also going up the big hill to regroup with everyon	Emerging-2
		Working in the cold	Emerging-2
		When it was really wet and windy out	Emerging-2
		The least enjoyable aspect in my perspective was doing the restoration work in winter when it was so cold	Mature-1
		Going to the nature sanctuary when it was wet and cold outside	Mature-1
		Smelling the compost	Emerging-3
		Feeding the worms with the food scraps. I guess it was fun but a bit gross	Emerging-3
		Going to the park which was just because my allergies made it difficult to concentrate	Emerging-4
		Didn't enjoy walking	Mature-2
		The fauna because I don't like bugs	Mature-2
		Learning outside, I would much rather a classroom	Mature-2
	Difficulty caretaking	When we picked up the trash it was cold and windy. Most of the trash had blown away	Emerging-2
		Garbage clean up was hard to find anything but still a good way to explore land with closer precision and socialize	Emerging-2
		Restoration at some times	Mature-2
		Almost falling down the hill while doing restoration work	Mature-2

Already present, unsure, or no change	It was fun, but I am not influenced	Emerging-1
	Idk maybe? It was a fun experience and I learnt some cool stuff	Emerging-1
	Didn't feel an influence	Emerging-1
	No, I do not think it influenced me in anyway possible	Emerging-1
	I feel pretty much the same as I did at the start	Emerging-1
	No, I already felt it	Emerging-2
	I think I was already pretty good about that I've grown up on beaches and in the forest, so caretaking for the environment is natural for me	Emerging-2
	I feel pretty much the same as I did at the start	Emerging-2
	Nah, I like it just as much	Emerging-2
	No, I have alays felt personally responsible towardsnature. I do not do things that badly affect the environment like littering. But I do not feel responsible for others actions towards nature, CO2 gasses, melting icebergs. I suppose I feel more caretaking towards nature near me, especially the animals	Emerging-2
	Yes but I don't know how	Emerging-2
	Not really	Emerging-2
	Not sure	Emerging-2
	I'm not sure, I don't think so but it was still an enjoyable experience	Emerging-2
	I still care a lot about it.	Mature-1
	I don't know. I grew up camping and being outside a ton, plus having Indigenous family that already gave me these lessons	Mature-1
	Nope!	Mature-1
	Not really, I'm already a responsible person	Emerging-3
	It didn't change my pre-existing opinions or knowledge, but I found it fulfilling never the less	Emerging-4
	It didn't change much	Emerging-4
	Not really, most of the program ideals aligned with my own	Emerging-4
	It honestly didn't really influence my feelings of responsibility but it did make me more understanding	Mature-2
	I don't think it really did aside from now I know certain plant species are invasive	Mature-2

	No it didn't	Mature-2
	No it didn't change my feelings of responsibility	Mature-2
Lack of control over learning / curricula	Really wasn't crazy about the group work. Especially the indoor photosynthesis lesson. I feel better solo because I am good at interpreting my ideas and not so great with others' ideas.	Emerging-1
	Indoor class was least enjoyable	Emerging-1
	Writing stuff outside	Emerging-2
	Drawing things because I am bad at it	Emerging-2
	Identifying species	Emerging-2
	Uninteresting	Emerging-2
	Journaling	Mature-1
	Going outside and not being able to make our own teams for jeopardy	Emerging-3
	Paper work	Emerging-3
	The slideshows	Emerging-4
	We had classes on Thursdays so work blocks for projects and learning time in our class was minimal	Emerging-4
	I didn't really find some of the activities engaging especially some of the more memorization focused one	Emerging-4
	I wasn't the biggest fan of the rhythm of your appearances. I thought the class was pretty infrequent and irregular. Besides that however it was amazing	Emerging-4
	Work sheets	Mature-2

Appendix 3.2 Sample questions for semi-structured post-program focus groups with students.

- Can you tell me a little about what things you remember learning (stick)?
- What would you have liked to learn more about (seed)?
- How did you find the activities? What was your favourite? When did you enjoy learning the most? The least? What could we do to make science/class more fun? Is there any kind of learning or approach you would've liked to do more of?
- Did the lessons impact the way you think or feel about nature, pollinators, plants, etc.?
- Do you feel that this program shifted your relationships to nature in any way (e.g., to worms, to soil animals, to food, to the environment, etc.)
- Overall, do you feel this program impact your relationship or connection with nature (or place)? Or feelings of environmental responsibility, or caretaking towards nature?

- Do you feel that this program impacted your sense of stewardship or environmental responsibility in any way? (intention? Empowerment?)
- What were the best parts of this program? What were the worst, or something challenging (stone)? What would you change for next time?
- Anything else you'd like to add while you have me here?

Appendix 3.3 Sample questions for semi-structured closing conversations with main teacher collaborators.

In your opinion,

- General impressions of the program?
- What were the strengths of the programs?
- Where do you think they could be changed or modified for next time?
- If you saw any trends in development over time—like from our first to the last program—what did we do more of or less of that you think were adaptive changes?
- Anything around development or implementation? Taking stock of student interest before the program—does that seem to work well?
- How can we best support Indigenous education?
- What are the barriers to implementing similar outdoor environmental education programs at broader scales? (e.g, district wide)
- What are some opportunities for implementing similar outdoor environmental education programs at broader scales? (e.g, district wide adoption, provincial?
- What is your definition, understanding, or vision of student success?
- What is your definition, understanding, or vision of program/course/curriculum success?
- What would you as a teacher want to see evaluated in these programs? E.g., if we implement this program again next year, is there any specific aspect of student achievement or learning that you think should be measured?
- What topics do you feel are important to include? How about competencies?
- Is there anything else you'd like to add for evaluating or modifying the program?

Conclusion

The aims of this dissertation were to develop (Chapter 1), implement (Chapter 2), and evaluate (Chapter 3) school-based environmental education programs that braid Indigenous and Western Science in two distinct curricular contexts. Six programs were developed, implemented, and evaluated using community-engaged approaches across contexts varying in program duration, class size, teaching resources, and other characteristics. These programs aimed to enhance environmental knowledge, relationships with nature, engagement with material, and environmental attitudes through weaving Indigenous and Western Science perspectives and practices with experiential, community-engaged, and outdoor learning.

The Introduction provided an overview of the program contexts and relationship-building processes. Chapter One introduced a program development checklist created through years of community engagement. Chapter Two examined process evaluations, highlighting strengths related to pedagogies and Indigenous Science, as well as challenges in conducting evaluations across contexts. Chapter Three analyzed program outcomes, finding that qualitative feedback was more effective in capturing impacts.

This current conclusive chapter offers a reflective analysis of the entire process. I begin by summarizing key findings, then turn to the two main threads I perceive as guiding this work: Indigenous education (IE) and developmental evaluation (DE). I engage in reflection of each in turn, starting with Cajete's (2010) principles of IE, exploring how IE was (or could have been) supported in different program phases (Table 00.1). Then I then delve deeper into the role of DE and its presence in program phases (Table 00.2). Next, I discuss main themes I have identified in my research which include both IE and DE. As someone who values frameworks and tools that enhance my thinking, these reflections grounded in the principles of Cajete (2010) and DE

represent my efforts to synthesize my research, and I offer more elaboration, anecdotes, and insights as I explore the themes that I identified.

I close by reflecting on how this research journey has catalyzed my own process of self-discovery and transformation. Amid the global environmental crisis, school-based programming can be an effective grassroots approach to deepening students' connection with the natural world and nurturing a strong sense of environmental stewardship. As demonstrated by my research, DE facilitates the incorporation of Indigenous pedagogy into EE programs, helping to create culturally responsive and community-engaged programs that benefit learners, communities, and the environment.

Summary of Key Findings

Program development entailed integrating the people, places, and pedagogies involved in the program, as well as exploring positionality for conducting culturally responsive program research as a non-Indigenous person. Planning evaluation strategies for implementation and outcome evaluation were also explored. These program components—positionality, people, places, pedagogies, planning for evaluation—were integrated into a checklist to aid developing school-based EE programs that braid Indigenous and Western Science. With the complexity offered by different school contexts, the shifting elements within a school, the multiple roles and responsibilities of myself as a community-engaged program researcher, and the respectful integration of Indigenous and Western knowledges by a non-Indigenous person, a checklist emerged as a tool that could organize my thinking and action while accommodating a range of collaborative approaches to program development. As a neurodiverse educator, I found the checklist especially useful in structuring and clarifying complex processes, making it a valuable tool for navigating various program elements. Using a systems thinking approach, if

positionality, people, places, pedagogies and program planning are parts of a machine, iteration, reflexivity, and reflection, are cogs that allow the machine (program checklist) to function as intended and enable ongoing adaptation and improvement.

Program implementation involved the carrying out of program activities on a day-to-day basis. Braided education poses logistical challenges given by the focus on outdoor, experiential, and community-engaged learning involved in these programs, plus different curricular characteristics (e.g., class sizes, timing and duration of lessons, educational supports) can further challenge implementing programs. Process evaluations were conducted to detect implementation challenges and identify program factors that were linked to implementation success. Program pedagogies shone through as main implementation successes enhancing student engagement, and grounding program sessions with Indigenous Science protocols (e.g., opening and closing in circle) added much-needed structure in outdoor education and a gateway to more relational and reflective processes needed for braided-styles of learning. Developmental evaluation was carried out through the continuous refinement of program activities gleaned through informal and formal conversations with students and teacher collaborators before, during, and after sessions, supplemented with my observations as program coordinator. Challenges with implementation across the six distinct programs revolved around balancing breadth and depth with content delivery and leveraging both instruction and exploration for learning. Indigenous Science content and protocols were continually revisited through reflexivity and reflection to ensure the respectful inclusion of Indigenous knowledge as learned through my experience in the education community.

Program outcomes were assessed through multiple methods—quantitatively through pre- and post-program surveys and qualitatively through open-ended written responses, written

student work, and verbal feedback provided from focus groups. The goals of outcome evaluation were to assess how these school-based braided EE programs impacted four dimensions of learning: environmental knowledge (intellectual), environmental attitudes (emotional), relationships with nature (spiritual), and engagement with material (physical). Positive program impacts were detected across all dimensions to varying degrees for each program. Qualitative feedback provided a more comprehensive and context-rich understanding of learning, in contrast to the quantitative surveys, which provided a more explicit look at score differences and was able to detect impacts of program characteristics (e.g., curricular context, season) on scores. Content analysis was applied to the qualitative data and key themes were identified through iterative coding. Factors that facilitated learning across the four dimensions included experiential learning, social ties and relationships, and inclusion of novel plants and animals. Service-learning, hands-on exploration, the routine associated with EE lessons, and learning about nature in nature were subthemes of experiential learning. Environmental awareness emerged as its own theme along with related subthemes of environmental attitudes and action competence. Several barriers to learning outcomes were also detected; these included physical challenges and discomfort; difficulty conducting caretaking, lack of control over learning, and attitudes already present or no change experienced. Findings from these outcome evaluations underscore the need for qualitative feedback as a key source of data in evaluations to both capture the nuances in participant experiences and ensures culturally responsive evaluation techniques. Further reflections on cultural responsiveness of program curricula are provided in the next section.

Reflecting on the Indigenous Education Principles Across Programs Phases

The Rumi quote I included in the Dedication section of this dissertation—"being guided by fragrance is a hundred times better than following tracks"—reminds me of the "learning spirit"

that Battiste (2013) discusses. Despite not having all the disciplinary-specific knowledge or formal training at the outset, my spirit intuitively led me into spaces where I could do the most good and learn the most at the same time (at least that's how I understand the purpose of life). This notion of being guided by the intuitive learning spirit strongly resonates with Cajete's (2010) principles of Indigenous education, particularly those addressing wounding, reflection, community, and creativity. As these principles have been pivotal in my own personal growth journey, especially when I encountered them during my candidacy exams, I felt it fitting to retroactively reflect on how these principles were present in my research in this dissertation. Retrospective reflection is also an important function in developmental evaluation (Quinn Patton, 2011). I also find Cajete's (2010) framework compelling because they offer an accessible framework for me, as a non-Indigenous, neurodiverse person, to reflect on how aspects of Indigenous education were or were not incorporated into the programs. In Table 00.1, I analyze Cajete's (2010) principles of Indigenous education in relation to the programs I have helped create and explore how these principles were active—or sometimes absent—across different program phases: development, implementation, and evaluation.

Table 00.1 Reflections and implications for developing, implementing, and evaluating school-based braided EE programs using Cajete's (2010) elements of Indigenous education as a guiding framework.

Cajete's (2010) element	General reflections on braided EE programs	Implications for development	Implications for implementation	Implications for evaluation	Insights or recommendations from practical experience
1. The idea that learning happens of its own accord if the individual has learned how to relate with his/her inner Center and the natural world.	• Each learner has a unique learning trajectory. • Conventional evaluations may not fully capture the individual pace and style of learning.	• Ensure program evaluation tools are designed with have open-ended questions and qualitative assessments can be effective in capturing the nuanced and personal aspects of learning.	• Facilitate engagement with nature in unique ways. • Include opportunities for solitary learning and reflection	• Use qualitative feedback and personal reflections to understand deeper relationships.	• Immersive unstructured experiences and journals were effective in capturing individual learning • Having students help design programs helped align curriculum with their personal interests and learning styles
2. There was the acceptance that at times experiences of significant hardship were a necessary part of an individual's education and that such	• Difficult experiences are often private and may not be visible in evaluations. - Learning still occurs despite challenges	• Reflect on how challenges are integrated into learning.	• Offer challenging experiences and support through difficult moments.	• Assess how well students navigate and grow from difficult experiences.	• Integrate opportunities that push learners beyond their comfort zones (e.g., working with new people, trying new skills, learning new topics). • Address physical and emotional

circumstances provided ideal moments for creative					challenges as teachable moments. • Use these moments to demonstrate the value of perseverance.
3. Empathy and affection are key elements in learning. Also, direct subjective experience, combined with affective reflection, are essential elements of "right" education.	• Emotional connection and empathy are crucial for learning. • Modelling respect and enthusiasm enhance the learning environment. • Creating opportunities for subjective experiences are crucial for fostering empathy and emotional connection in learners.	• Design activities that engage learners on multiple dimensions (physical, emotional, intellectual, spiritual) • Embed opportunities for empathy and emotional processing.	• Engaging all dimensions of the learner (physical, emotional, intellectual, spiritual) enhances the overall educational experience.	• Evaluate how emotional engagement impacts learning outcomes. • Reflect on the role of positive social relationships and emotional support in facilitating effective learning.	• Positive social relationships and interactions with animals facilitated learning in our programs
4. An innate respect for the individual uniqueness of each person which gave rise to the	• Diverse learning styles should be acknowledged and supported.	• Incorporate a variety of activities, topics, and pedagogies.	• Adapt instruction to the unique strengths and needs of students.	• Reflect on how well the program adapts to different learning styles and adapt for	• Balance between instruction and student-led exploration.

understanding that ultimately each person was their own teacher as far as understanding and realization of their process of individuation.	• One-size-fits-all approaches may not be effective.			next program iteration.	• Implement free-choice and project-based learning.
5. Each learning situation is unique and innately tied to the creative capacity of the learner.	• A single lesson can provide varied experiences for different students. • Diversity in instruction can capture a wider range of learning impacts.	• Provide opportunities for creative expression and problem-solving.	• Provide opportunities for creative expression and problem-solving.	• Assess how diverse experiences are captured and valued.	• Use art and creative assignments to capture varied learning experiences. • Recognize and support individual creativity.
6. Teaching and learning are a collaborative cooperative contract between the "teacher" and learner. Foster collaboration between instructors and participants; build those	• Effective teaching involves building collaborative relationships. • Both teacher and learner contribute to the learning process.	• Foster collaboration and build strong relationships between instructors and students.	• Utilize non-teaching moments (e.g., breaks, walks) for relationship building.	• Evaluate the strength of collaborative relationships and their impact on learning outcomes. • Reflect on how well the program	• In the Mature context, more effort could be made to engage with students individually and use informal moments for connection. • Accept the trade-offs in relationship building and trust

relationships for effective learning.				supports and leverages these relationships.	the primary instructor-student relationships. • Embrace reciprocal learning and remain reflexive about one's role in the learning process.
7. Learners need to see, feel and visualize a teaching through their own and other people's perspectives.	• Programs benefit from integrating various perspectives and experiences. • Encouraging students to view situations from different angles fosters deeper understanding.	• Draw on diverse community members for engagement and learning. • Create opportunities for shared reflection, such as group circles or discussions.	• Recognize that participation and engagement will vary among students and tailor approaches accordingly.	• Evaluate how well the program incorporates diverse perspectives and how students are encouraged to reflect on these. • Assess the effectiveness of shared reflection activities and community engagement in enhancing learning.	• Incorporate multiple viewpoints by involving a range of community members and perspectives. • Implement regular opportunities for group reflection to deepen understanding and community relationships. • Recognize and accommodate diverse ways students engage and participate.
8. There are basic developmental orientations involved with	• Students within the same cohort may be at different stages	• Design program activities that accommodate varying levels of	• Develop flexible strategies to address diverse	• Evaluate how effectively the program supports	• Implement strategies for individualized support and

learning through which we must pass toward more complete understanding.	of growth and have varying perspectives. • It's essential to respect and support each student's unique journey and offer tailored assistance.	development and perspectives. • Provide differentiated support based on individual needs and growth stages.	learner needs within the same grade or cohort.	learners at different stages of their journey. • Assess the relevance and impact of the supports provided on individual growth and learning outcomes.	differentiation in programming. • Regularly assess and adjust support mechanisms to align with students' varying stages of development. • Create a learning environment that values and nurtures diverse growth trajectories.
9. Life itself is the greatest teacher and each must accept the hard realities of life with those that are joyous and pleasing.	• Real-life challenges and mistakes can be powerful teachers. • Viewing mistakes through a strength-based lens helps recognize their role in growth and learning.	• Design programs to incorporate real-life experiences and challenges, such as through service-learning projects.	• Emphasize learning from mistakes and failures as part of the educational process.	• Assess how the program integrates real-life experiences and challenges into the learning process. • Reflect on the balance between theoretical knowledge and practical, lived experience.	• Utilize mistakes and challenges as teachable moments, reinforcing their value in the learning process. • Ensure that the program includes opportunities for students to engage with and reflect on real-life challenges. • Foster an environment where both successes and mistakes are seen as

					integral to growth and learning.
10. Learning through reflection and sharing of experience in community allows us to understand our learning in the context of greater wholes.	• Bringing in individuals with varied perspectives as guest speakers enriches the learning environment. • It's crucial to ensure that the program's message aligns with the desires and stances of community partners.	• Invite guest speakers and community members from diverse backgrounds to share their experiences. • Be mindful of and align with the values and messages of community partners.	• Use sharing circles and group reflections to facilitate the exchange of perspectives.	• Evaluate the effectiveness of incorporating diverse perspectives by gathering feedback on how well students feel they have been exposed to different viewpoints. • Assess whether the program's message is consistent with community partners' desires and stances.	

Reflecting on the Presence of Developmental Evaluation Across Programs Phases

Cajete's (2010) principles emphasize that learning is a deeply individualized and often non-linear journey, which resonates with the principles of DE, which also values flexibility and responsiveness to the evolving needs of the program and its participants (Quinn Patton, 2011). Both Cajete's approach and DE advocate for a reflective, long-term perspective that recognizes that success and growth can look different for each learner (or program). Shifting from the reflections on how IE was or could have been better supported in the program phases, I now turn to a similar examination but for principles of DE.

I begin by discussing the strengths of each curricular context (Mature, Emerging) from an evaluation perspective and explain how DE facilitated evaluations in both contexts. In, Table 00.2, I highlight key elements of Quinn Patton's (2011) DE and reflect on how these aspects were applied across different phases of the programs. Interestingly, DE as an evaluation approach was not selected from the outset but rather emerged organically as the best fit for developing, implementing, and evaluating braided EE programs. This aligns with DE's inherent quality of accommodating processes of emergence and unfolding.

Different educational contexts presented inherent trade-offs in terms of time, resources, and student numbers, which influenced development, implementation, and evaluation. The key activities and opportunities for evaluation varied significantly between the Emerging and Mature contexts. The Emerging context facilitated closer relationships with students, as there was more collaboration with the class in planning topics, approaches, and evaluation techniques, which resulted in a more grassroots program, integrating feedback and adapting to students' needs in real time. Although assessment techniques were limited to the program sessions themselves, the informal and ongoing conversations aligned with Indigenous oral traditions, fostering deeper

relationships among participants and with myself as program coordinator. In contrast, the Mature context presented challenges in building close relationships due to the fast-paced program and larger student body. Strategies such as station-based learning were employed to manage the high number of students, which reduced interaction time.

Despite the challenge with building relationships with students, the relationship with my collaborator remained strong, providing valuable insights through their assessments and conversations with students. The Mature context offered more established evaluation techniques, including photo journals, newsletters, and student reflections, which were integrated into the curriculum and provided comprehensive evidence for both formative and summative evaluations. These differences highlighted how curricular structures impacted both process and outcome evaluation. The Mature context's established assessment tools provided extensive evidence for evaluation, while the Emerging context's informal approaches aligned with Indigenous pedagogy, both offering valuable insights into program effectiveness.

Table 00.2. Elements of developmental evaluation (Quinn Patton, 2011) in the school-based EE programs that braid Indigenous and Western Science.

Elements of developmental evaluation	**Description**	**How DE was applied in developing, implementing, and evaluating the programs**
Adaptation, iteration, responsive adjustments, feedback loops	• Programs are continuously refined based on real-time feedback and learning • As new insights emerge from implementation, immediate adjustments can be made • Feedback loops promote continuous improvement	• Informal conversations before, during, and after program sessions provided real-time feedback • **Lesson to lesson:** As different teaching strategies and content delivery approaches were tested earlier in program implementation, they were either kept or removed in later implementation (e.g., timing of opening circles, exclusion of post-lesson reflections) • **Program to program:** gradual increase of experiential, community-engaged and service learning based on success from previous implementations

		• Regular check-ins with program collaborators can identify areas for enhancement and ensure that the program remains aligned with its goals and community needs • The two contrasting contexts provided venues in which tactics and approaches could be applied in one context, evaluated, and adjusted for the other.
Collaboration	• Stakeholders are involved in the program development process to ensure community values and priorities are being upheld • Fostering trust and collaboration among the team is important for accountability	• Checking in with priorities and values important at beginning of program process and revisit as needed • Program team members involved in program development, implementation and evaluation to varying degrees based on investment in program • Collaboration styles aligned with preferences/needs of collaborators (e.g., community events, workshops, informal or formal meetings and conversations)
Focus on learning & reflection	• Participants and collaborators feel safe to share their experiences, challenges, and successes. • Reflective practice can lead to deeper insights and collective learning • Experimentation and innovation allow for new ideas and approaches to be tested without fear of failure.	• Post-lesson conversations with collaborators proved most fruitful for garnering successes and challenges with development, implementation, and evaluation processes. • Practitioner reflection critical to identify patterns and mechanisms underlying program successes or obstacles. • Shared/group learning benefits students in terms of hearing different perspectives. • Reflection on program coordinator's personal insights, experiences and dreams also guided the program
Multiple sources of data & real-time feedback	• Methods for data collection are flexible and dependent on context and intended use. • Collecting data in real-time allows for immediate insights that can inform ongoing program adjustments	• Informal and formal conversations, interviews, focus groups, surveys, student work, observations, practitioner field notes and reflections • Capitalizing on opportunities for evaluation with different program team members (during lesson; post-lesson) • Qualitative feedback necessary for capturing nuances of participant experiences and ensuring culturally responsive evaluation techniques

		• Documenting observations and Activites immediately after occurrence • Next time, consider integrating written feedback faster (e.g., reading student work immediately and incorporating feedback during program, instead of the integrating into the next cycle of programming). • Next time, consider implementing mid-program feedback (e.g., sharing circle or focus groups) for what is working well in the program and what could be changed for the remaining sessions.
Context & complexity	• Program decisions (e.g., evaluation approaches, adjustments to program activities) are context dependent • Understanding the unique cultural, social, and environmental factors at play, program coordinators can create more effective and culturally responsive programs that meet the needs of the context, collaborators, or participants. • Explores emergent issues and interplay of various factors influencing program success.	• "Emerging" and "Mature" presented two different contexts in which different approaches were taken for relationship-building, evaluation, and program delivery. • For example, in the Mature context, more formal written feedback was utilized, while in the Emerging context, verbal feedback and opportunistic conversations were more prevalent.

Key Themes Across Program Phases

Throughout all phases of the program—development, implementation, and outcomes—several recurring themes emerged through my own analysis of my chapters and reflection on what I have done and learned over the last several years. These themes are worth exploring in detail as they consistently appeared across each phase, can be considered the foundational pillars for this family of programs, and in my view, integrate elements of both Indigenous education and DE.

1. Community engagement & relationships. Collaboration and nurturing relationships with educators, students, educational assistants, Indigenous knowledge keepers, community members, and Elders were crucial to shaping and implementing the programs. The program development phase was particularly focused on relationship-building, with early interactions providing critical insights that tailored the program to local needs and contexts. Engaging in conversations, attending community events and workshops, and incorporating local protocols with permission were integral to creating curricula that resonated with all involved. This phase emphasized relational accountability—showing up, listening, and being present—which remained important through the program and helped integrate local knowledge and protocols with mindfulness and intention.

While much of the learning about program fit and relationship-building with students occurred during the implementation phase, conducting a preliminary assessment was crucial. Some cohorts were more academically-focused and thrived on a defined topic with specific activities, while other cohorts that had diverse learning needs and attendance challenges benefitted more from varied topics and semi-structured activities. This initial relationship-building phase, before full-scale implementation, is vital for establishing trust and respect with students and tailoring the learning experience to the unique needs of the cohort. The implementation phase highlighted the significance of community engagement as an effective pedagogic strategy, whether through having local community members or scientists provide more context on a topic (e.g., Mature-1; Mature-2; Emerging-3; Emerging-4). In terms of outcomes, social ties played a crucial role in facilitating learning, as peer or familial interactions gave an opportunity for students to share learning or put what was learned into action; these

patterns were notable in programs that incorporated service learning (Mature-1, Mature-2, Emerging-3, Emerging-4).

2. Flexibility & adaptation. Flexibility is a recurring theme throughout this research. Each program iteration offered unique opportunities for growth, aligning with developmental evaluation's emphasis on adaptability and responsiveness (Table 00.2). When developing programs, educators needed to be open to adapting curricula based on the program context, emerging opportunities, the rhythm of student interest, and natural cycles. The program development chapter discussed how curricula were reviewed through different "lenses" to ensure that key program elements were being met. During implementation, real-time assessments and adaptations were made, particularly in response to student participation and feedback, allowing for immediate adjustments to better accommodate diverse needs and enhance inclusivity. These real-time adaptations were more easily achieved in the Emerging context, where smaller class sizes and shorter class times provided greater flexibility.

Adaptability also played a significant role in ongoing refinement during implementation, particularly through the use of process evaluations. These evaluations enabled continuous adjustments to content delivery, pedagogical approaches, and lesson structures, informed by feedback from both students and educators. Flexibility was equally important in outcome evaluations, as different cohorts had varying communication preferences (e.g., focus groups vs. sharing circles, written vs. verbal feedback), and each context came with unique constraints, such as time and the number of class sessions. Recognizing what worked well while staying open to adjustments was essential for creating responsive and effective learning experiences that met the needs of participants, the environment, and collaborators.

3. Experiential learning. Learning from experience emerged as a key theme across program development, implementation, and outcome evaluation. Developmental evaluation, which values trial-and-error and the exploration of new techniques, underscores the importance of learning through doing. This approach was evident throughout the development and implementation processes, as well as in the feedback exchanges between these phases. Reflecting on my journey, I acknowledged moments of uncertainty and embraced cycles of action and reflection. Process evaluations identified experiential learning as a major strength in implementation, and outcome evaluations further revealed its role as a crucial facilitator of enhanced learning outcomes. The study demonstrated that hands-on, experiential learning was essential for improving students' environmental knowledge and attitudes, fostering relationships with nature, and engaging with the material.

4. Culturally responsive pedagogies. Culturally responsive pedagogies emphasize the importance of positioning oneself authentically (Pirbhai-Illich et al., 2017). For me, this meant becoming more than just an instructor and presenting myself as a multi-dimensional person. This approach aimed to challenge settler colonial structures that often benefit certain genders, sexualities, ages, and neurotypes, thereby creating space for more inclusive expressions of identity. It aligned with my personal experiences and desire for decolonization, fostering an environment where students felt free to express their unique selves. The significance of building genuine relationships was highlighted through continual feedback, where students valued the informal conversations during our journeys to and from the park. Instilling a sense of belonging in all learners is central to Indigenous education (Accord on Indigenous Education, 2010).

A key theme of this research is the importance of braiding Indigenous and Western Science to create a more holistic and inclusive approach to environmental education. Being

responsive to the program context and opportunities facilitated a mosaic-like approach to program development, where elements from both Indigenous and Western pedagogies were brought together respectfully and intentionally. Building and maintaining relationships with community members and adhering to cultural protocols enriched the learning experience and strengthened the program's relevance. Indigenous Science protocols, such as opening and closing circles, added structure and preserved the integrity of the braided programming. Integrating diverse perspectives, including those from Indigenous educators involved in this work, and scholars like Kimmerer (Citizen Potawatomi), helped instill a sense of gratitude and responsibility towards nature, contributing to relational and attitudinal shifts in students. Increased engagement with material was facilitated through aspects of Indigenous pedagogy, such as learning outdoors.

5. Reflexivity & reflection. The need for reflexivity in educational practices is a necessity at every program phase, to ensure cultural responsiveness and facilitate personal growth. Reflexivity played a role in program development as reflecting critically on my experiences, dreams, and interactions contributed to my understanding of effective program practices. Balancing this internal guidance with external guidance from collaborators, literature, and community was important at all three stages. Acknowledging one's own biases, experiences, and intersectionality can lead to more inclusive and effective educational practices. Scrutinizing curricula with different lenses can also help create inclusive programming. I had shared how dreams often provided insights into program planning and curricular content, reinforcing the importance of reflection and paying attention to intuition. The checklist encourages the integration of inclusivity and intersectionality into program development. I reflected on my own positionality as a non-Indigenous, neurodiverse educator and how this affected the design and

implementation of curricula. This reflection on intersectionality helped me understand the diverse needs of participants and create more inclusive learning environments. During implementation, I reflected on the importance of being aware of one's positionality, particularly as a non-Indigenous educator, and the necessity of engaging in reflexive practices to ensure that Indigenous content is delivered respectfully and authentically, and teaching and learning are approached with humility.

Writing deeply about the programs that were conducted also led me to reflect on the iterations that weren't carried out. In thinking about program development, I came to realize how vital reflection was to the process—particularly in deciding which paths to pursue and which to let go. There were early ideas for the program that, despite their potential, never came to fruition. For example, at one point I envisioned integrating an ecological assessment as a central element of the program. This would have shaped both program preparation and the evaluation of how students and ecosystems responded to restoration efforts. However, that plan did not pan out, which led me to question whether I had made the right choices—a moment I captured in the following journal entry:

> **01/17/2023:** Just looking at the old plans and condensing them in one place. At one point I envisioned that I would do a whole bunch of ecological work. This would set the tone for chapter 2, which would discuss program preparation, and speak to how both the ecosystem and students responded to restoration. I just didn't do it. It didn't come up in me. There was no fire there. I have to trust the fire. I am a very passionate person. Yes, there's a lot of fear in me too. But I believe that if I was really meant to go down this route, I would have. I tried. I tried preparing. But it just didn't pan out, and I am choosing to trust that that was OK.

This reflection highlights an important aspect of the program development process: the need to trust in the momentum of the program and recognize when certain paths are not aligned with the direction the program is taking. It could also be considered as moment when I was trusting my

learning spirit. While the ecological assessment could have been valuable, it was not the right fit at the time. Reflection allowed me to be adaptive, letting the program evolve organically rather than forcing it into predetermined molds. This also underscores the role of the community as a guiding force, like a center of gravity, pulling the program toward where it needed to go. Another way reflection was utilized in this research was by integrating systems thinking to gain insights on evaluation post-program, key aspects of developmental evaluation (Quinn Patton, 2011). This approach is illustrated by an infographic that draws parallels between evaluation and composting process drawn through reflection after teaching the composting program (Emerging-3; Figure 00.1). Integration of systems thinking with developmental evaluation in EE can highlight interrelationships between educational and evaluation contexts (Drossman, 2024).

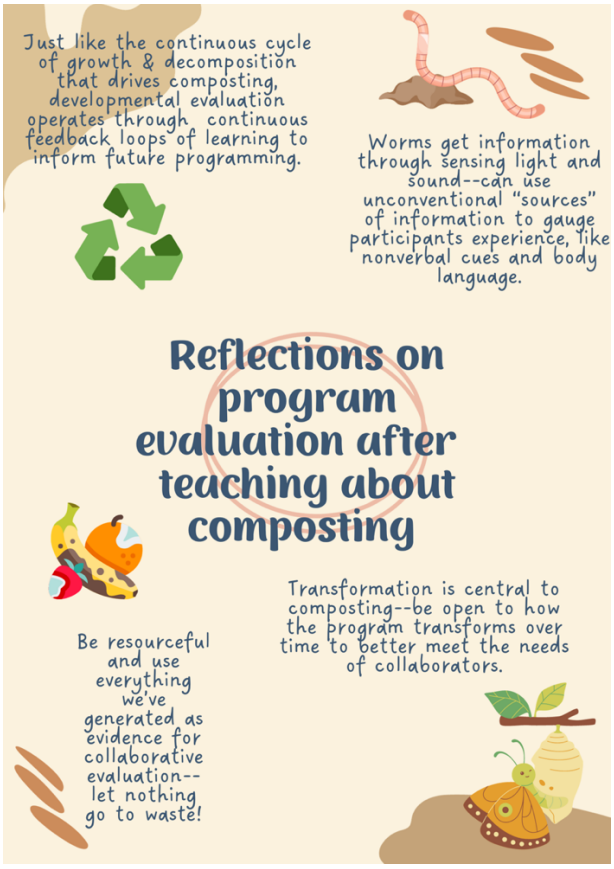

Figure 00.1. Insights resulting from bridging composting and evaluation with systems thinking and reflection to glean insights on developmental evaluation for program refinement.

6. Collaborating with the natural world. In *Decolonizing Education* (2013), Mi'kmaq educator Marie Battiste (Potlotek First Nation) describes learning as "nourishing the learning spirit," where the spirit embarks on a journey to acquire essential knowledge. This concept resonated deeply during a bird observation lesson in Emerging-2. An initially disengaged student later shared an enthusiastic report about a colorful bird, linking it to a favourite movie. They described the bird's behavior in vivid detail, and this newfound enthusiasm significantly boosted their engagement in the rest of the program. This experience was a profound realization for me: the transformative learning emerged from the student's interactions with nature itself versus my direct influence. My role was to facilitate meaningful experiences through connecting youth to land. This instance highlighted how collaborating with the natural world can enhance learning and underscored the importance of trusting both the process and students' innate learning spirits (Battiste, 2013). Attuning to the natural world and leveraging its rhythms were essential for program development and being responsive during program implementation. Animals and exploring the land were themes that facilitated learning across all dimensions (environmental knowledge and attitudes, relationships with nature, engagement with material) when looking at program outcomes.

7. Being process oriented. One of the most valuable insights is the importance of being process-oriented rather than goal-oriented, especially in Indigenous contexts (Simpson, 2002). Building relationships with the land and community required time, patience, and reflection, consistent with Cajete's (2000, 2010) reflections on Indigenous Science and education. Being process-oriented also resonates with developmental evaluation, which focuses on emergent findings rather than fixed outcomes (Quinn Patton, 2011). Being process-oriented was crucial not only for building relationships and developing programs but also for continuously refining them during

implementation. Even when outcomes were fixed (e.g., focusing on environmental knowledge, attitudes, relationships with nature, etc.), capturing them effectively required qualitative data gathered through ongoing evaluation processes, rather than relying solely on pre- and post-program surveys administered at fixed timepoints.

8. Shifting roles. Evidence of shifting roles for both me, as program coordinator, and participating students across program phases became evident upon reflection. The community-engaged nature of relationship-building required adopting various roles such as listener, supporter, instructor, community member, visitor, and witness; reflexivity was essential in navigating these diverse contexts and determining which role should be prioritized at any given time. In terms of students, shifting decision-making power to participants made programs more successful. Youth can actively participate in evaluations by providing feedback on curriculum and program structure, engaging with the community, and collaborating with educators and researchers (Agirreazkuenaga, 2022). Programs where students directly influenced the curriculum during program development resulted in curricula that prioritized student interests and preferences. For program implementation and outcomes, programs that had more free-choice learning and unstructured time were highlights of those programs. The iterative nature of developmental evaluation allowed for more opportunities for students to shape development, guide implementation, and steer their learning outcomes with each iteration, as feedback was continuously incorporated to refine the program.

Roles and responsibilities shifted according to the needs of each context, highlighting contextual differences. In the Mature context, I primarily acted as an observer and supporter, collaborating with colleagues who had established ideas and required assistance in execution. In contrast, in the Emerging context, I assumed a leadership role, working closely with students to

co-create the program. This feedback—observing and supporting in one context while leading in another—offered valuable opportunities for both professional and personal growth, aligning with the learning feedback loops emphasized in developmental evaluation (Quinn Patton, 2011).

Conclusion

Indigenous pedagogy describes learning as a process of 'coming to know' (Snively & Williams, 2016), where significant hardship can serve as a catalyst for renewal and transformation (Cajete, 2010). I have come to deeply understand this through feedback between my personal and professional experiences. Throughout the course of my PhD, I've been on a journey of healing from significant childhood trauma, including confronting familial abuse, discovering my autism and ADHD diagnoses, and learning more about myself in ways I had not anticipated. Much of this personal journey was catalyzed by the work I undertook in this project. Without the challenges and the need for deep self-reflection that came with this work, I don't believe I would have been compelled to face these difficult questions about privilege, power, recovery, and identity that ultimately led to my becoming, or "coming to know," myself.

My passion and inspiration for this research are rooted in my own experiences of childhood trauma and recovery, which involved experiential, nature-based learning and learning about the wisdom of plants through scientific research. Once I fully realized and began to confront my trauma as an adult, I felt an undeniable calling to drop what I had been doing and begin this research. What began as developing programs which cultivate resilient traits in youth meandered and evolved into the work it is today. In many ways, the values I aim to instill in these programs—learning with and in community, prioritizing relationships, healing in nature, strength-based lenses, weaving multiple perspectives, holistic approaches, adaptive and iterative refinement of process, reflection, and the importance of lived experience or learning by doing—

are the very values I've come to live by in my own recovery. These principles have shaped my understanding of researcher reliability, as well as my personal journey toward healing. This project, while academic in nature, has ultimately become a reflection of my own process of self-discovery and transformation, and I am deeply grateful for all the people and places that have made this work possible.

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