SPECIAL ISSUE: Disrupting and Decentring Dominant Science Education Teaching Practices

New Day - Herbert Shane Hartman

SFU ED REVIEW

SIMON FRASER UNIVERSITY EDUCATIONAL REVIEW JOURNAL

Volume 15

Number 1

Winter 2023

ISSN 1916-050X (online)

sfuedreview.org

COVER ARTIST BIO

Artist Herbert Shane Hartman

Herbert Shane Hartman is a proud member of the Nakaz'dli Whut'en First Nation from the Dakelth or Carrier people in the Central Interior of British Columbia. Shane is a self-taught artist working with simple minimalist style to convey the feelings of his artwork. Shane has tried various media types in the past, but now works predominantly with gouache and paper for his paintings, and with an iPad and Procreate for his digital pieces. As an artist Shane enjoys finding new ideas for artwork, and feels that starting a new artworks is a great way to start a new day. Shane is an avid golfer, downhill skier and less than average fisherman. Shane has also completed his Master's Degree in Natural Resources and Environmental Studies, and cares deeply about nature and the planet. Shane currently resides in Victoria, BC with his wife, daughter and border-doodle dog.

Shane's first children's book titled "Isla's New Drum " was written for his daughter and to share the rich Carrier Dakelh culture to the world. Read more about Shane here: https://www.indigenousauthor.com/

ABOUT THE ARTWORK

New Day

In the spirit of Indigenous storytelling and cultural significance, the artwork portrays a profound narrative. At its core is the image of a radiant light bulb, its rays symbolizing the birth of a new idea, akin to the moment when a light bulb ignites in one's mind. Yet, within this light resides a Raven, a sacred and central figure in many coastal First Nations stories. Raven embodies the timeless tale of light, a story woven through the fabric of Indigenous cultures.

The mountains stretching in the background are a symbol to the North Shore mountains, a place stewarded by Indigenous Peoples for centuries. They stand tall, as guardians of ancient wisdom, and bear witness to the ever-evolving landscape around them. They also represent Burnaby Mountain, the home of Simon Fraser University, a place of learning and growth.

The waters that flow beneath symbolize the ocean, a constant presence in the lower mainland, reflecting the deep connection Indigenous peoples have with the land and sea. It is a reminder of the enduring relationship between Indigenous Peoples and their environment, nurturing wisdom that continues to shine brightly, like the light bulb in the artwork.

This creation represents a bridge and a way of seeing and being that weave scientific ideas and ancestral stories - a way towards relational teaching that brings spirit, heart, and mind back to science.

SIMON FRASER UNIVERSITY EDUCATIONAL REVIEW JOURNAL

Table Of Contents

SPONSORS AND PARTNERS

Sponsors

SIMON FRASER UNIVERSITY
Faculty of Education

Partners

SFU EDUCATION GRADUATE STUDENT ASSOCIATION

ABOUT SFU EDUCATIONAL REVIEW JOURNAL

We respectfully acknowledge that at SFU's three campuses, where our journal is edited and distributed, we live, learn and work on the unceded traditional territories of the Coast Salish peoples including the Squamish, Tsleil-Waututh, Musqueam, Semiahmoo, Kwantlen, Katzie, Kwikwetlem, Qayqayt and the Tsawwassen First Nations. We also note that, as the University remained closed, many of us continued working from home in British Columbia and across Canada. We acknowledge the many Native communities around Canada on which we as First nations people, as settlers and as uninvited guests have been living, working, and learning.

SFU Educational Review Journal is a graduate student-run journal at Simon Fraser University and supports diverse scholarship in the field of Education. The journal is fully open access. We practice a double-blinded review process to ensure the highest quality of submissions. We aim to publish three issues per year, with one issue focused on specific themes from the educational field.
All our issues are published online at *www.sfuedreview.org* and are publicly accessible.
Editorial Team:

- Daniel Ferraz
- Livia Poljak
- Shaila Shams

A brief history: The SFU Ed Review published its inaugural first issue in the spring of 2007. Originally, the Ed Review followed a traditional academic journal format; however, in 2012, the Ed Review was redesigned in order to make it more welcoming and accessible. Through these changes the Ed Review hopes to:

- be more inclusive of our academic community;
- promote discussion and reflection;
- provide a medium that better supports diverse scholarship and research;
- provide a format that better supports shorter works.

Ultimately, we are hoping to initiate a medium that will promote better awareness about the current work being pursued in the Educational community, offer a safe environment for peer-to-peer dialogue, and encourage emergent scholars to explore and develop their own voice within academia.

Contact Information:	8888 University Drive
SFU Educational Review Journal	Burnaby, BC Canada
Faculty of Education	V5A 1S6
Simon Fraser University	sfuedr@sfu.ca
	sfuedreview.org

LETTER FROM THE INVITED CO-EDITORS

In the ever-evolving landscape of education, STEM (Science, Technology, Engineering, and Mathematics) and STEAM (Science, Technology, Engineering, Arts, and Mathematics) approaches have emerged as pivotal paradigms, catalyzing interdisciplinary and cross-disciplinary learning, fostering critical thinking, and nurturing problem-solving skills. These methodologies have garnered substantial recognition within research and pedagogical practices, facilitating diverse conceptions that blend the realms of art, technology, science, and mathematics.

Contemplating the conventional Eurocentric or Western scientific focus in school science (Aikenhead & Elliot, 2010), it is evident that multiple ways of knowing and being have been inadequately represented. For over two decades, researchers and educators have grappled with the challenge of introducing alternative knowledge systems into a predominantly Western and Eurocentric educational structure (Higgins, 2014).

In response to these challenges, the Canadian educational system has shown a burgeoning interest in centralizing Indigenous perspectives and dismantling Eurocentric structures that often mold science education. This involves concerted efforts in research, professional development, and teaching practices to create inclusive science spaces that respect diverse worldviews while countering systemic barriers to equitable science education (Smith, Avraamidou, & Adams, 2022). For the first time in SFU Ed Review's history, this special issue disrupts traditional approaches to sharing work with the community by not only inviting participation and contributions from local and national science educators, but to open teaching science from different disciplines. More importantly, the editors of this special issue invited Herbert Shane Hartman, an Indigenous author and artist who is a member of the Beaver or Lhts'umusuyoo Clan from the Nak'azdli Whut'en First Nation located near Fort St. James, British Columbia, Canada, in conversation about the importance of language and knowledge preservation and its role in education. We are honoured to feature his original artwork, titled, ***New Day*** on the cover.

Shane's deep connection and commitment to his community and culture is reflected in his work and art. Shane is a self-taught artist working with simple minimalist style to convey the feelings of his artwork. Shane predominantly works with gouache and paper for his paintings, and with an iPad and Procreate for his digital pieces. As an artist Shane enjoys finding new ideas for artwork and feels that starting a new artwork is a great way to start a new day. Shane has also completed his Master's Degree in Natural Resources and Environmental Studies. On behalf of the journal and the Simon Fraser University community, we are honoured for Shane to share an original piece of artwork for the journal's cover. We encourage each reader to begin by reading the meaning behind Shane's art to truly understand the connections between each story.

This special issue seeks to explore and disseminate scholarly insights and practical knowledge across a spectrum of domains that are instrumental in shaping the future of STEM/STEAM education. This issue is divided into sections that spotlights STEM/STEAM educator voices from academia, community, students and educators. Authors have been encouraged to decenter expectations of academic writing and instead, to write from a place of heart, lived experiences, and stories that speak true to their everyday living, teaching, and learning. Moreso, this issue is divided into sections to capture the diversity of voices and contributions to the science education field. The sections are:

Theoretical and Conceptual Paradigms: This section delves into the theoretical frameworks and conceptual models that challenge traditional disciplinary boundaries. These frameworks are pivotal in the promotion of integrated STEM/STEAM teaching practices, which are at the forefront of educational innovation. In the anchor article, **Getting back to the real world: creative approaches to science literacy, problem solving and cultural inquiry,** Zandvliet discusses how STEM/STEAM frameworks dominate science education discussions, often with Eurocentric focus. STEM is primarily used in education policies to enhance science and technology competitiveness, with gaps in representation. This approach can reinforce hegemonic beliefs and overlook social and environmental issues. This paper suggests reframing science education around biocultural diversity, Two-Eyed seeing, and guided inquiry, fostering interdisciplinary practices centered on student and community needs, promoting creative science literacy, problem solving, and cultural inquiry. As we move beyond geographical boundaries on STEM education, Ogunlade, a professor at the University of Science Education and Technology Ikere in Nigeria discusses the importance of incorporating STEM/STEAM in early childhood education in an African context. In her article, **A Novel Pedagogical tool for childhood education in STEM and STEAM towards Achieving Sustainable Development Goals in Africa,** critically reviews early childhood education in Africa, examining its impact, benefits, challenges, and potential solutions. It analyzes theoretical frameworks, pedagogical tools, and practical experiences, including non-formal and community-linked STEM and STEAM approaches in Ekiti State, Nigeria. The study highlights the significant role of culture and environmental influence on learning. In the article **Steam and English for Specific Purposes: Online Courses for Brazilian Students in Technology,** Nunes and Barcelos invite us to question our understanding of informal English courses, particularly ESP ones, which, according to them, should be designed by an interdisciplinary group of professionals, such as language teachers and specialists in the area, in order to show a meaningful learning experience. In this way, this text aimed to analyze three informal online English courses designed for Brazilian students/professionals in technology considering the ESP and STEAM approaches and compare them with university learners' needs.

Community-based Science Education Research: This section spotlights personal narratives from non-formal educators who implement programs in science museums and similar environments. These narratives offer insights into real-world experiences. Additionally, innovative pedagogical approaches tailored for non-formal STEM/STEAM education prioritize hands-on learning, inquiry-based methods, and interactive experiences. Moreover, collaborative efforts and partnerships between science museums, educational institutions, and the broader community are instrumental in enhancing STEM/STEAM learning opportunities, making education more accessible and impactful. In **Science in Informal Learning Spaces: Tinkering Space at Science World,** Lee shares her lived teaching experience in tinkering spaces. She further highlights that establishing tinkering spaces in informal learning settings necessitates research, testing, prototyping, and evaluation. The design and programming are often iterative and time-consuming. A science museum like Science World, for example, employs a collaborative design process to create tinkering spaces. The Tinkering Space's creation prioritizes the visitor's experience, resulting in a thoughtful and well-designed environment. A group of ten environmental educators from the Vancouver Botanical Gardens Association is actively involved in community-based STEAM education.

In **Fostering a Lifelong Love of Plants: Educator Stories from a Botanical Garden,** Martin et al., share their experiences in connecting people to the plants at VanDusen Botanical Garden and Bloedel Conservatory, situated on the ancestral lands of the xʷməθkwəy̓əm (Musqueam), Skwxwú7mesh (Squamish), and Sə̓lilwətaʔ/Selilwitulh (Tsleil-Waututh) Nations. Their experiences collectively emphasize the importance of nature in STEAM education. Their narrative illustrates that successful STEAM education thrives through collaborative efforts, embracing new educational opportunities, place-based experiential learning, and the inclusion of diverse perspectives, recognizing the impact of personal experiences on worldviews, and fostering a love for the natural world. In **History Teaching in a Museological Space: an Experience at the Rio Grande do Sul Memorial, Brazil**, Stelmach explored the narrative of the mediated educational action on the itinerant exhibition "Monuments and Art: the history of the city at risk", which exposed a series of monuments and public statues taken from the streets of Porto Alegre. Thus, this paper aimed to discuss issues concerning the teaching of History in museological spaces, based on the narrative of an experience at the Rio Grande do Sul Memorial, a place that generated the teaching-learning process of students who visited this space.

Student Voices: This section highlights personal narratives that encompass a young learner's learning journey and encounters within STEM/STEAM classrooms. These stories reflect not only moments of challenge but also growth, inspiration, and creativity experienced in the learning environment. These narratives share a profound impact of how science is taught and how various teaching approaches encountered by a young learner have the potential to alter or transform their perspective and emotions towards science. These experiences contribute to a

broader understanding of the dynamics of STEM/STEAM education and its influence on young individuals. Mukherjee, a high school senior, reflects on her scientific journey in a computational biology laboratory and how the frustrations of the scientific process can become key learning moments. Her article, **Cell Death & Certainty,** is a personal narrative of Mukherjee's lived experience as a young STEM student.

In her article, **Tackling Demotivation in STEM Fields: A Student's Perspective,** Pandrangi, a freshman or first-year undergraduate student, recounts her STEM journey in high school. She discusses how domains of STEM/STEAM, where curiosity and creativity converge with high rigor, maintaining motivation and self-belief can be challenging. Self-doubt often looms for students like Pandrangi.. In this account, she shares her struggles in the STEM journey, specifically with a high school chemistry class and science fairs. Despite moments of discouragement, she found growth and inspiration, which now propels her to continue to embark on a career in STEM. In **The Influence of a STEM/STEAM Education Based High School on Students of the Ivoti Institute,** Richner explains all the benefits and opportunities that STEM/STEAM educational setting brings to the students in Brazil, and how it has affected his life personally. For that matter, this text aimed to determine the difference between the STEM/STEAM education High School model and the Traditional Basic General education High School Model. Another important objective is to explain the benefits of the STEM/STEAM High School format being implemented in the Ivoti Institute, in Rio Grande do Sul, Brazil.

Educators' Reflections: This section highlights teachers and educators' reflections on their lived experiences in the context of STEM and STEAM education. These articles offer insights into integrating arts and aesthetics into STEM, highlighting strategies to nurture creativity and innovation within the STEM/STEAM curriculum. The educators also share their personal reflections on the challenges encountered while implementing disruptive STEM/STEAM education methods. In **Disrupting STEM Education by Braiding Indigenous Ways of Knowing and Environmental Education,** Dodier explores the importance of acknowledging one's feelings, the power of storytelling, my journey educating myself and embracing multiple perspectives inside my teaching practice. According to the author, it is time to disrupt traditional STEM education by meaningfully embracing multiple perspectives such as Indigenous and environmental education learning principles. In **School Leadership Development for Sustainability in the Post-Digital Era,** Awodiji, Uleanya and Naicker examine school leadership development in a post-digital era from the sustainability perspective. According to them, to ensure sustainable education, school leaders must have relevant skills and competencies to lead schools in the post-digital age.

In the interview **Struggles and Triumphs of an Early Childhood STEM Educator: Why Connections Matter? An Interview with Ms. Jade Leong,** a researcher and an early childhood educator exploring pedagogical approaches to teach STEM to children aged 1 to 5. The conversation reveals insights into early childhood education challenges and solutions. Through the interview, it becomes evident that STEM training for teachers can be attributed to increased teacher confidence to teach science. The interview exposes a key issue—early childhood educators often are not given opportunities for professional development in teaching math and science, and may potentially impact teacher self-efficacy and quality of STEM education. In **Scientific Dissemination Practices in Basic Education: Reflections on a Brazilian Experience in a Public Technical School,** Campani assumes that it is a basic school commitment to contribute to scientific dissemination, scientific literacy, and the establishment of a culture of science in society, especially in Brazil, a country where scientific denialism is still very present. The purpose of this text is to reflect on the challenges and results of a practical experience with scientific dissemination at the Fundação Escola Técnica Liberato Salzano Vieira da Cunha, a public technical high school in Novo Hamburgo, Rio Grande do Sul, Brazil.

Artistic and Creative Expressions: In this section, authors present their creative works that challenge traditional science education teaching approaches, offering a fresh perspective on the integration of art in STEM/STEAM education. Authors share their lived creative expressions to delve into the intersection between STEM and the arts. Each artistic expression showcases the authors' process through mind, body, and heart on what it means to enact STEAM. The creative piece **Decoding**, by Asel, metaphorically represents the dyslexic experience, in which neurodivergent individuals who have dyslexia may struggle with the daily decoding of information within their cognitive load. His goal is to foster empathy towards neurodivergent individuals, countering stereotypes associated with people like himself. The creative piece, **Proposing How Art Could Be Used to Educate Science,** by Hoang Do, examines theories and examples between art and science, showing where they are similar, and how art and design can be used to educate and inform scientific data. The author aimed to do so by focusing on and comparing theories of physics, mainly those related to Isaac Newton, and art and design's color theories, showing how they are similar, and then proposing how art could be a bridge between science and the learner, how knowledge could be delivered as an experience.

The creative paper **Critical Pedagogy: a Creative Artistic Representation about Paulo Freire's Work,** by Hoerlle and Ribas, shows us the importance of Freire's way of teaching and, after all, his contributions to a non-traditional teaching. To do so, from a theoretical point of view, it drew on Giroux (1989), with regard to the critical pedagogy, based on Freire's work. In **Integrating Art Into STEM: An Intersubjective and Participatory Experience with Fellow Subjects,** Behrisch discusses the importance of integrating art into STEM to allow learners to have an immersive connection with their subjects, in stark contrast to traditional STEM's belief

in separation from the world they study. Artistic practices like oil painting in STEM promote intersubjectivity, valuing emotional responses as data. Behrisch adds that this approach fosters a sense of kinship, shifting from objectification to connection. Behrisch's painting process illustrates a participatory relationship with a wild doe, yielding diverse subjectivities in a collaborative, intersubjective experience. This concept draws on David Abram and Goethe's theories of embodied knowledge and participatory observation.

We encourage our readers to explore this issue, delving into the heart, lived experiences, and stories that reflect the true essence of teaching, learning, and living in a diverse and inclusive educational landscape. It is a celebration of the connections between these diverse stories that will lead us toward a more equitable, rich, and inclusive future in science education.

Sincerely,

Poh Tan, PhD (Exp. Med), PhD ABD (Sci. Educ.)
Simon Fraser University, Canada
Invited Co-editor

Eduardo Glück, PhD (ABD)
Unisinos University, Brazil
Invited Co-editor

SFU Educational Review
Simon Fraser University
e: sfuedr@sfu.ca
w: sfuedreview.org

SPECIAL THANKS

On behalf of the editors and invited editors, we would like to extend our heartfelt gratitude to the dedicated individuals who have played an integral role in the success of this special issue of SFU Educational Review. To our esteemed contributors, your passion, expertise, and insightful contributions have enriched our publication, sparking meaningful conversations in the realm of science education. We appreciate the tireless efforts of our copy editor, Shaila Shams, whose meticulous work ensured the clarity and precision of every word. To the managing editor, Daniel Ferraz, your continued support for this special issue is deeply appreciated. Last but not least, we are grateful to our talented layout editor, Hoang Do, whose creative vision and attention to detail have brought our content to life. Together, all of you have made this special issue of the SFU Educational Review a platform for knowledge and innovation, and for that, we say thank you from the bottom of our hearts.

About the Invited Editorial Team:

Dr. Poh Tan: Poh, a dedicated educator, scholar, and accomplished scientist, completing her second PhD in Education at SFU, while also serving as an invited editor for SFU Educational Review. Her academic journey is fueled by a commitment to fostering societal change, particularly by challenging traditional teaching practices as a science educator. Poh's notable achievements include receiving the 2023 Mantella Corporation BIPOC Entrepreneur Award and a nomination for the 2023 YWCA Women of Distinction Award. As an advocate for diversity in STEM, she actively promotes inclusivity and challenges stereotypes. Poh's leadership extends to roles like past-president elect of the Society for Canadian Women in Science and Technology (SCWIST) and founder of STEMedge Inc. She strives towards inspiring women and girls, especially those from underrepresented backgrounds, to pursue STEM and education careers, free from stereotypes, embodying the belief that embracing uniqueness is a wellspring of strength.

Eduardo Gluck: Eduardo Paré Glück holds a master's degree in applied Linguistics from UNISINOS University, and he is a PhD candidate at the same university. He has concluded his doctoral internship at the Linguistics Research Centre of NOVA University Lisbon (CLUNL). Specialist in English Language Teaching Methodology at Universidade Paulista. Graduated in Language, with qualifications in Portuguese Language, English Language and Literature from UNISINOS University. Researcher member of the research group Science Communication: Linguistic and Technodiscursive Studies, coordinated by Prof. Dr Maria Eduarda Giering, from Unisinos University. He is a member of the editorial board of the LER Project – Literature and Science.

Hoang Do: Hoang is from Vietnam and is currently a Bachelor's of Design student at Emily Carr University of Art and Design in Vancouver, Canada. Having an interest in physics but simultaneously struggling to understand it, he feels that art and design is one of the best ways to make science and learning about science interesting and exciting to learn. He has collaborated with Poh and the Vancouver Botanical Gardens Association to create Bloedel Conservatory's first science outreach activity booklet for teachers and their classrooms. As the layout editor for this special issue, Hoang was inspired to submit his own works of creative expressions.

ARTICLES

THEORETICAL AND CONCEPTUAL PARADIGMS

GETTING BACK TO THE REAL WORLD: CREATIVE APPROACHES TO SCIENCE LITERACY, PROBLEM SOLVING AND CULTURAL INQUIRY

DAVID ZANDVLIET
Simon Fraser University
UNESCO Chair, Biocultural Diversity and Education.
Institute for Environmental Learning.

Abstract

*Today**,** STEM and/or STEAM frameworks dominate the discourse around science education and what constitutes a 'scientific' literacy**.** While no one definition prevails in the literature, this literacy is often defined in the context of a current national concerns and focuses largely on Eurocentric (western) models of science and/ or scientific knowledge in terms of concepts, models, theories, or principles. As it currently stands, the term STEM is mostly used when addressing educational policy and curriculum choices in schools, aimed at improving competitiveness in science and technology with implications for workforce and economic development (often with some missing voices from women and Indigenous communities). Without an important socio-cultural critique, education of this kind can maintain and promote hegemonic beliefs and values while ignoring collateral problems relating to scientific or technological development: many of which have been linked to social and environmental injustice. In this paper, I offer three perspectives in an effort to decentre the discourse around the STEM movement. Using the overlapping themes of biocultural diversity, Two-Eyed seeing and guided inquiry, I offer suggestions on how to reframe science education as an interdisciplinary practice centred on student and community needs. In these ways, science education can 'get back to the real world' and promote creative approaches to science literacy, problem solving and cultural inquiry.*

Introduction and Background

In contextualizing this paper which I have been invited to share, I preface it by saying that I don't do not view myself, or my work as being centered in a traditional model of science education 'per se' despite a formal training in the discipline. I am also not a big fan of the STEM or STEAM acronyms with accompanying frameworks that are now dominating the discourse around science education. However, having stated this bias clearly, perhaps this stance is a good perspective to take in a special issue with the stated aims of "disrupting and decentering dominant teaching practices in science education." To make this point clearer, I have titled this paper: *Getting back to the real world: creative approaches to science literacy, problem solving and cultural inquiry*.

To begin this argument, I note that the concept of 'science' literacy has been an important component of education reform agendas worldwide for some time, and while no one definition of scientific literacy prevails in the literature, it is often defined in the context of a current national concerns and focuses largely on Eurocentric (western) models of science and/ or scientific knowledge in terms of concepts, models, theories, and principles that all students ought to know, understand and use. However, this definition does not address diverse audiences' (especially women and minorities). Roth and Barton argued that this is due to science classes becoming, "mechanisms for controlling what it means to know and do science" rather than a source of empowerment where students are valued for their abilities to contribute to, critique, and partake in a just society (Roth & Barton, 2004).

Common usage of the 'STEM' acronym to describe the current round of curricular reforms arose shortly after an interagency meeting on science education held in the U.S. in 1998 by the National Science Foundation (NSF). At that meeting, after first expressing some discomfort for the older acronym (METS), the NSF instituted the change to the current, more popular acronym. As it reads now, STEM aims at integrating outcomes and skills related to its constituent elements or disciplines, namely: Science, Technology, Engineering and Mathematics. Since that time, the STEM designation has been applied broadly to a variety of projects and programs worldwide.

Since STEM was first conceived, there has been increasing momentum, funds and energy aimed at implementing 'integrated' models of STEM education in schools. These integrated models typically refer to at least two or more of the discipline areas being applied together to solve problems or to make/design products. However, despite publicity around the reforms, and the substantial amount of funding available, it is still prudent to ask if STEM education (alone) is capable of achieving the outcomes that are expected of it (Zandvliet, 2018). What are the overarching goals of the STEM movement? What other efforts will be needed to ensure its success?

In many countries, STEM innovations are considered by national governments to be the key to obtaining a global, economic future and so, increasing funds, time and energy are being put into improving STEM education (European Union, 2015; Hackling, Murcia, West, & Anderson, 2014). Still, since the inception of STEM and the literally billions of dollars in

expenditure, the early results have been mixed. Simply put, these initiatives have not created the desired increase in students selecting STEM subjects in school or an expected increase in STEM graduates from postsecondary institutions (Burke & Baker McNeill, 2011). Blackly and Sheffield (2015) stated that this problem lies with the *E* of STEM noting that *Engineering* is not a subject in public schools. Despite this, others have suggested that the E in STEM might equally represent an E for *Economy*, as the growth in STEM innovations is seen as a way forward to securing a strong economy with highly capable workers for the future (Chubb, 2015, Zandvliet, 2018).

Blackly and Sheffield (2015) argued earlier for another type of *E* for STEM – possibly that of *E* for *Ethics* or even an *E* for *Environment* as possibly more appropriate visions for science education reform. From the perspective of the reform movement, and for new models of teaching and learning, it is indeed feasible that scientific, technological or environmental topics form a more authentic context for learning, thereby making science content more meaningful to students. In turn, this might facilitate deeper understanding of the subject matter: a key goal of current reform efforts in science education. Still, within a largely economically motivated STEM model – 'environmental' or 'cultural' topics are most often reduced to the simple transmission of knowledge (Sammel and Zandvliet, 2003).

Another movement can be found in the evolving STEAM framework. This can be described as an approach to learning that espouses the disciplines of Science, Technology, Engineering, the Arts and Mathematics as access points for student inquiry, dialogue, and critical thinking (see Figure 1). STEAM projects are considered to be science-based, but also incorporate artistic expression. Advocates for this approach argue that this will produce students who take risks, engage in experiential learning and persist in problem-solving. Many science educators are not convinced that adding an *A* to STEM is beneficial. In fact, some critics see it as a dilution of STEM's focus and objectives. These advocates for STEM caution against expansion to STEAM arguing that while it may be beneficial for students to have exposure to the arts, those pushing it are considered external to the STEM community.

Figure 1: *A play on words*

As it currently stands, the term STEM is mostly used when addressing educational policy and curriculum choices in schools, aimed at improving competitiveness in science and technology with implications for workforce and economic development. In this, I must echo my earlier critique of science education reforms as they uncritically promoted economic rationalism with the goals of increased national competitive advantage and the growth and legitimacy of science and technology and engineering-based industries while other important concerns for social and environmental justice take a distant second place to the demands of international competitiveness (Zandvliet, 2018).

Without an important socio-cultural critique, education of this kind can work to maintain and promote hegemonic beliefs and values, ignoring collateral problems relating to scientific or technological development: many of which have been linked to social and environmental injustice. Still, this critique is not about condemning all the STEM initiatives but rather, exploring how these situate science within political agendas. Indeed, scientific facts and information are needed, but if they are only presented in neutralized forms, are disconnected from other social constructions, then we are not communicating to students the strengths and limitations of the Western traditions of science or indeed, what it means to be scientifically literate.

Biocultural Diversity as a 'Provocation'

Moving on from the critique of the STEM / STEAM movements, I'd I would like to offer a simple provocation towards another view of contextualizing science education. In the past I have argued for a more inclusive, 'ecological' framework for science education (Zandvliet, 2010). Put simply, this connotes an emphasis on the inescapable 'embeddedness' of human beings and their technologies in natural systems, instead of considering nature as the 'other.' Ecological frameworks view the human enterprise as one part of the natural world and human societies and cultures as essentially an outgrowth of interactions between our species and particular places (Smith & Williams, 1999). Such an approach to science education would also allow educators to consider multiple perspectives on an issue or problem. This line of inquiry eventually took me to consider more deeply the concept of 'biocultural diversity' as central in my work (Zandvliet et. al. 2023).

Biocultural diversity as defined by Maffi (2007) can be described as 'the diversity of life in all its manifestations: biological, cultural, and linguistic — which are interrelated within a complex socioecological adaptive system.' Maffi further relates that this diversity is made up not only of the diversity of plants and animal species, habitatshabitats, and ecosystems, but also of the diversity of human cultures and languages. While positive correlations have been described between biological diversity and linguistic diversity (for example), my research has focused more centrally on social factors such as educational/cultural practices, as these have been found to uniquely influence biocultural diversity.

It is important to note that the concept of bio-cultural diversity is dynamic in nature and takes the local values and practices of different cultural groups as its starting point for sustainable living. For educators, the issue is to work to preserve / restore important practices and values, but also to modify, adapt and create diversity in ways that resonate with diverse urban and rural communities. In this research, bio-cultural diversity is conceived as a reflexive and sensitizing concept that can be used to assess the different values and knowledge of all people – as a reflection on how we live now and in the future with biodiversity. As such, the concept must also be closely tied to issues of teaching and learning.

This type of research also gives attention to issues of power or privilege (using a critical pedagogy stance) as these are mediating factors within the education milieu – particularly with reference to government mandated curriculums and teacher training practices. As Donald (2019) frames it, "the origin of current human struggles to balance the desire for economic development with ecological sustainability derives from a deep forgetting of…simple truths" (p.104). Biocultural research and practice aim to deeply describe the simple truth of our inter-relatedness and interdependence.

The notion of bio-cultural diversity is also related to the Indigenous concept of land as first teacher. Positioning 'land' as a source of knowledge brings into focus the importance of this relationship. As Michell (2018) phrased it, "we are the land, and the land is part of us. We are the context…When one aspect of nature is out of balance, all forms of life are affected" (p. 17). Beyond considerations inter-relatedness, the concept of land as teacher also implies responsibility. To acknowledge that we belong to the land means we also have a duty to maintain good relations with it. For Styres (2011), "when land informs reflective practice, pedagogy and storying, everything starts with and returns to the land, self is not/cannot be set apart from the interconnected and interdependent relationships embodied in land" (p. 718).

So now, what would such a biocultural framework look like in practice? To introduce this idea, I offer up a short case study of some curriculum pieces from my on-going work with student teachers in the context of Haida Gwaii. The coursework is offered as an intensive 2-3 week2–3-week series of field experiences set in the community of Skidegate (Education 452) and the following vignettes are excepted from a collection of case studies recently published in a volume of Indigenous science education research and resources (Alsop et. al., in press).

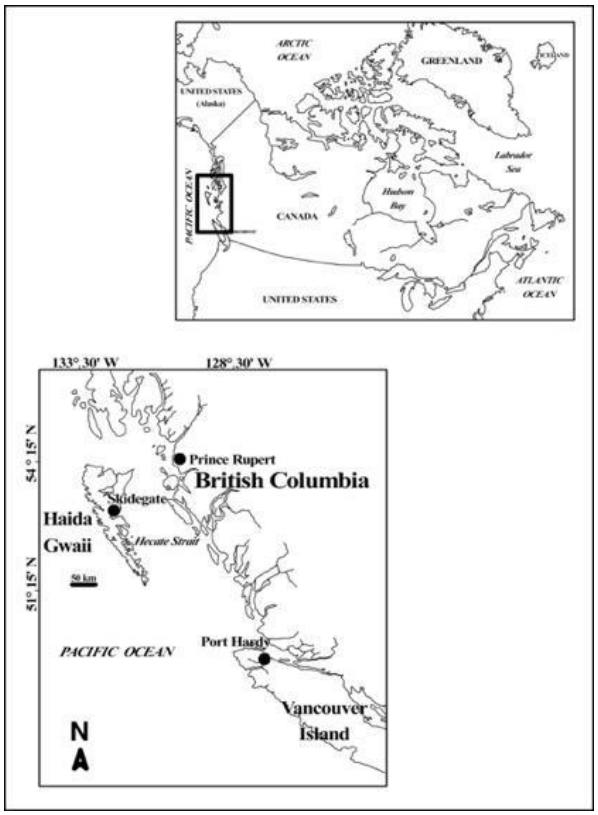
Case Study: Haida Gwaii

When Xā'gi emerged from the waters, Foam-Woman was sitting upon it. Around the edges of the reef were other supernatural beings, but she permitted none of them to come near. If anyone attempted it, she looked at him and winked her eyes, when lightning shot forth and drove him back. From this she was also called She-of-the-Powerful-Face. When Djila'qons [Jiila Kuns], the grandmother of the Eagles, approached, Foam-Woman said, "Keep away from here before I look at you;"and when she did look, Djila'qons "went down." Others say, perhaps out of respect

to the Eagle side, that the latter was one of two beings able to approach. The other was a mouse, which, however, grew smaller and smaller as it came. That is why mice are so small today ...
[Swanton, 1905a:p75]

Scientists believe that many glaciations have occurred on Haida Gwaii and geological evidence of the most recent (Late Wisconsin Glaciation) is most commonly found. Even at the glacial maximum, some scientists believe that northeast Haida Gwaii and parts of the Hecate Strait remained ice-free. After the glacial maximum was reached, the global climate shifted dramatically, resulting in the melting and rapid retreat of ice. Scientists believe human migration to Haida Gwaii (and down the coast of British Columbia) occurred during these ice-free periods, somewhere between 15,000 and 10,000 before present.
[excerpt from a science lesson]

Figure 2. *Location and features of Haida Gwaii*



The above accounts are also excerpts from scientific, cultural exhibits displayed at the *Kay Llnagaay* Heritage Centre (*Kay*) in Skidegate and are referenced in the unit and lesson plans developed by SFU teacher education students. These writings form part of a unique and evolving educational experience on these islands located on the westernmost fringe of British Columbia forming part of the Pacific Rim. Texts such as these describe important aspects of a community unique in Canada for its connections between culture, ecology and the land. For these reasons, it is the location for a longstanding environmental education program offered in a collaborative partnership between the Haida Nation and SFU's Faculty of Education.

Science *and* Story

It [Xā'gi] came to the surface like a reef in the falling tide. On top of it a woman called Foam-Woman was sitting, and the families of supernatural beings swam over to it from all sides. Only those were there out of whom the present island families were going to come. Before this, when it was not yet on the surface, and the supernatural beings tried to climb on top of it, Foam-Woman refused to allow them to [let them out of the water]. Then they were afraid, and waited for it to come above the surface of the water, as she had said. When quite a piece of it was above the surface, they began to talk over where they were going to settle …
[Swanton 1905a:p76]

Scientists who study the geology of Haida Gwaii generally separate the islands and the surrounding marine area into two regions: the Queen Charlotte Ranges and Coastal Trough, including the Hecate Depression. These mountains run from southwestern Graham Island to Moresby Island and include the Skidegate Plateau. While the Queen Charlotte Ranges form the backbone of the islands, they are extremely rugged. The Coastal Trough is a marine area between the east coast of Haida Gwaii and the west coast of the British Columbia mainland.
[excerpt from a science lesson]

The survival of many elements of First Nations' Traditional Ecological Knowledge (TEK) despite the effects of Western expansion and policies such as forced resettlement, mission schooling, the outlawing of traditional practices such as: curtailing of traditional legal actions through banning of potlatches, underscores the strengths of these cultures and their continuity from past to present (Wilson et. al. 2005). For many First Nations such as the Haida, oral records form an integral element of their culture and are seen as key to their identity as people. These traditions can also provide a link to the past that is an important affirmation of the community in a Western-dominated world. Therefore, oral traditions are seen as a valid interpretation of the past and social relevance for the living.

Increasingly, anthropologists look at oral histories not as mere myth but as tools to unlock high-level cultural constructs or as illustrations of theories (Wilson et. al. 2005). In many parts of the world, oral history can be shown as an account of the past of a nation, that contains accurate information about past events or the past environmental actions. Anthropological research has demonstrated a connection between oral histories and pre-historic events. On Haida Gwaii, Swanton (1905a, 1905b), documented many oral histories with a deep time depth describing a time when Haida Gwaii was joined to the mainland, a time when the climate was much warmer, a time when it was cold, and a time before the first trees (Wilson et. al., 2005).

Many more cultural accounts now exist in written and recorded forms and still in the memories of Haida elders. These show the connection between the Haida and their land and give an idea of their length of inhabitation of these islands. Stories preserve information about the ancient past that cannot be obtained from Western sources, but they also store other important kinds of knowledge (eg. medicinal knowledge or environmental management practices). They

also ‘give roots’ to young people and instill pride in their connection to Haida Gwaii. This kind of understanding may assist us in moving towards a more sustainable relationship with the environment. This point also connects to another important development: the re-emergence of Indigenous forms of education (Lowan–Trudeau 2013).

Two-Eyed Seeing as an emergent practice.

The previous case study set as it was in the context of an Indigenous community (on Haida Gwaii) offers insights into the need to be more inclusive in the forms that science education curriculum may take in the future. Worldwide, there is a need to more deeply incorporate First Nations perspectives into the K-12 curriculum. This is due partly to influences such as the UN Declaration of the Rights of Indigenous Peoples (UNDRIP), which states that educators have a professional obligation to ensure the rights of all Indigenous peoples, and to include First Nations perspectives in their teaching (UN, 2007). This agenda requires a transition from colonial education systems to postcolonial and globalised approaches that recognize the importance of the knowledges and wisdom of Indigenous peoples and local communities (Anderson & Rhea, 2018). Countries such as Australia, Canada, and New Zealand have enacted policies through their teacher qualification standards and curricula that require educators to understand and include First nations ways of knowing and being to support reconciliation (e.g., Australian Institute for Teaching and School Leadership, 2022).

Further, according to the OECD (2020), *science identity* is also strongly linked to social justice, and is considered to be fundamental to science learning and achievement, perhaps as important as acquiring the knowledge and competencies of science. This concern stems from the question: “How can science teachers enable all students to study a Western scientific way of knowing and, at the same time, respect and access the ideas, beliefs, and values of non-Western cultures?” (Snively & Corsiglia, 2001, p. 24). Addressing this requires a recognition that “all science learning can be understood as a cultural” (National Research Council, 2012, p. 284), here, culture is reflected in peoples' and communities' identities through their ways of being, knowing, and relating to the world. Finally, teachers need to understand and support their students to engage in and through multiple ways of knowing (Bang & Medin, 2010) while recognising the potential for common ground.

This leads me to consider the idea of *Etuaptmumk* or *Two-Eyed Seeing.* This concept is based on the idea that both Indigenous and Western scientific ways of knowing are valuable, achievable, and can inform how we live in the world (Bartlett et al., 2012; Hatcher et al., 2009). This idea originated from Atlantic Canada in the traditional territory of the Mi’kma’ki people who have the longest Canadian history of living with colonizers, thereby providing their Elders with a unique understanding of Western perspectives (Hatcher et al., 2009). The Mi’kma’ki word *Etuaptmumk* means *the gift of multiple perspectives*. In 2004, the phrase *Two-Eyed Seeing* was coined by the Mi’kma’ki Elders Albert and Murdena Marshall, while working in collaboration with Professor Cheryl Bartlett (Bartlett et al., 2012).

Figure 3. *Etuaptmumk or Two-Eyed Seeing*

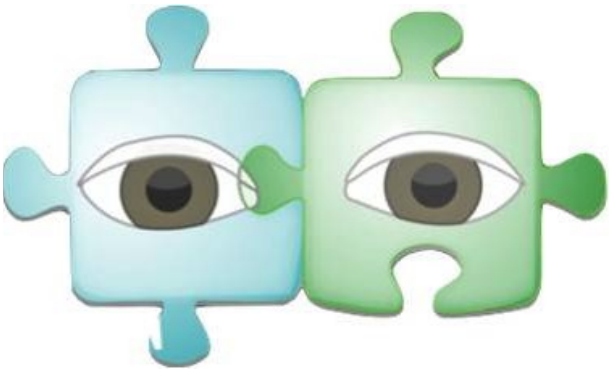


Image credit: Team of the Canada Research Chair in Integrative Science

in collaboration with Mi'kmaw Elders in Unama'ki / Cape Breton University.

In explaining the significance of Figure 3, the Elder (Albert) wrote: "the two jig-saw puzzle pieces help remind us that, with respect to [traditional knowledge], no one person ever has more than one small piece of the knowledge" (Bartlett et al., 2012, p. 336). Further, other pieces of the puzzle include the perspectives of different cultures, other living beings, and kin. This 'binocular view' supports a deeper, more generative field of view than would be achieved by either perspective in isolation (Iwama et al., 2009) Essentially this results in a richer understanding of the world (Roher et al., 2021).

Two-Eyed Seeing recognizes that both Indigenous and Western knowledge systems are whole and distinct in and of themselves (Roher et al., 2021). On either side of this model, knowledge holders are not asked to relinquish their position; instead, they work collaboratively across knowledge systems on a common problem to understand perspectives from both sides (Berkes, 2017). Avoiding false dichotomies, the model also assumes that both systems contribute to co-produce a pluralistic understanding that informs context-specific decisions that add to our understanding of the world (Bang, & Medin, 2010).

Within the model of Two-Eyed seeing, both systems offer valid, yet different understandings that act in tandem to create unique knowledge or innovations (Mistry & Berardi, 2016). The model also actively considers common ground, so that "Indigenous knowledge systems can be paired with revelatory Western scientific insights" (Reid et al., 2021, p. 245). Importantly, the model acknowledges the changing nature of knowledge systems from within our own perspectives. At Cape Breton University, Two-Eyed seeing was first applied to guide the development and implementation of an *Integrative Science* concentration within a four-year Bachelor of Science degree program for Indigenous students (Hatcher et al., 2009). The term *integrative* denotes the bringing together of knowledges and also emphasizes an ongoing process of knowledges travelling together. As a guiding principle, the model seeks to avoid knowledge domination and assimilation thereby preserving the integrity and authenticity of each knowledge system.

Key philosophies that informed the program were taken from Indigenous knowledges from across the globe, including concepts such the idea that all beings and natural elements are interconnected and interdependent (Cajete, 2000; Levac et al., 2018). In the model, humans are considered part of the natural world, albeit a very small part (Hatcher et al., 2009). Knowledge and the knowers are interconnected, and knowers bear a responsibility to act on that knowledge and this ethic of responsibility is extended to all beings—now for future generations (Bartlett et al., 2012). Since its inception, there are many good examples where the Two-Eyed Seeing approach has been applied in fields such as Education for Sustainable Development (Zeyer, 2022), fisheries (Reid et al, 2021), medicine (Hall et al., 2015), and wildlife health (Kutz & Tomaselli, 2019). In summary, the practice of Two-Eyed seeing presents some authentic and compelling possibilities for a more culturally inclusive form of science.

Interdisciplinary Knowledge and Guided Inquiry

Getting back to the idea of decolonizing or decentring the frameworks of STEM and STEAM that currently dominate science education discourse, it is important to note that at the core of any scientific enterprise (Indigenous or Western) is the practice of authentic and community-based inquiry. In my opinion, the practice of community-based inquiry may form the beginning of a potential 'common ground' that can form at the nexus of biocultural, Indigenous and Western ideas about science education. In a sense, this would essentially be about bringing education 'back to the real world' and getting more creative about what we mean about an interdisciplinary culture of inquiry.

Within the science education community, there has been a long-standing critique of teacher-centred approaches that are reliant on textbooks (Harlen & Bell, 2010; Osborne & Dillon, 2010). In fact, more than a century ago, John Dewey (1910, 1990) advocated for student-centred forms of inquiry. Inquiry-based teaching and learning is now thought to better reflect the practice of scientific inquiry and further refinements to this model have integrated additional discipline-specific approaches where students can engage directly in knowledge construction processes (Kenny & Cirkony, 2018). These involve teachers guiding students to create representations of phenomena (e.g., diagrams or models) and further, to use them to illustrate their ideas or justify claims (Tytler et al., 2013).

Given the long-standing calls for guided, inquiry-based approaches to education (e.g., Dewey 1910/1990; Deboer, 2006; Eberback & Hmelo-Silver, 2015; Harlen & Bell, 2010), many jurisdictions adapted a framework known as the *5E*s: A constructivist model to support teachers and learners of science. First introduced in the U.S. during the 1980s, it has been adopted in many places around the globe (Bybee et al., 2006). The model scaffolds teaching and learning using five iterative phases, those of: *Engage, Explore, Explain, Elaborate* and *Evaluate*, with each having a specific purpose in helping students build their understanding with the guidance of a teacher, in contrast to more teacher centred, transmissive approaches.

The *engage* phase is intended for students to "tune-in" to a topic and make connections with their current knowledge. Here, a teacher provides experiences to probe students' ideas about a given phenomenon. Students can express and share their ideas through various representations (e.g., diagrams, models, role plays) in combination with text or verbal explanations. In the *explore* phase the teacher prompts deeper and more scientific thinking though additional hand-on activities, or by posing follow-up questions to link the students' explanations to new evidence, or by asking students to compare divergent explanations.

In the *explain* phase, the teacher provides more (or different types) of information to the students. The teacher provides a range of experiences to build students reasoning and inquiry skills. This can involve facilitating discussion and debate among individuals and between groups of students. Importantly, a teacher must avoid moving to an explanation too soon. To support the development of conceptual learning, the teacher also gradually introduces new ideas, to ensure students are not simply memorising content. The teacher needs to judge when students are ready for the next stage: this may be through the teacher posing questions or making suggestions that extend students' ideas.

After further work in consolidating students' understanding, the process shifts to the *elaborate* phase where they apply their knowledge to solve a problem or do an investigation. Students then share their ideas through a range of representational forms and challenges. This helps to build inquiry skills and representational reasoning abilities (Cirkony & Kenny, 2022). Finally, the *evaluation* phase starts at the beginning of the process: as students share their ideas, and teachers receive feedback about students' learning. At the end of the sequence, students then demonstrate what they learned. This can include 'representation-rich' and interdisciplinary activities as well as more traditional methods of evaluation. Importantly, the 5Es model has also been adapted to accommodate First Nations perspectives. For example, a Canadian 7Es model is an enhanced and extended version of the 5Es, by its inclusion of the *Environment* and *Elders* (FNESC, 2016). This ensures lessons relate to the local environment to build an appreciation of connectedness and a sense of place.

The 7Es model promotes traditional ways of teaching and learning (e.g., guest speakers, guided-labs, field trips, formative assessment), and provides guidance for the development of lessons and units (FNESC p. 19). It is further supported by a framework for designing Indigenous science resources, which attempts to foreground Indigenous voices, languages, and diversity; protocols; relationships with the land; and ways of teaching and learning (FNESC, 2016). Teaching and learning in this way can involve experiential learning, storytelling, observations, visualisations, movement, students use of trial-and-error, and student directed research projects. Importantly, educators can also help to establish learning communities by experimenting with learning circles, cooperative problem-solving, and knowledge sharing without the need for a competitive ranking of performance.

As part of a culturally responsive curriculum developed earlier in the U.S., Stevens (2001) also compared traditional (Indigenous) forms of teaching with inquiry teaching (see Table 1). Here, where traditional teaching approaches involved expert knowledge placed alongside relevant and practical contexts, inquiry teaching placed teachers in the of facilitators of learning and emphasized student-centred methods. Together, these offer several strategies, highlighting the opportunity to integrate diverse expertise and perspectives, learning across the disciplines, and connecting learning to relevant community contexts.

Table 1. Similarities between traditional (Indigenous) teaching and learning and teaching using inquiry-based methods (adapted from Stephens, 2001, p. 28 as cited in Cirkony et.al 2023).

Traditional Teaching	**Inquiry Teaching**	**Compatible Strategies**
Can involve Elders, family, community and peers	Uses teacher as facilitator of learning; science is seen as a social endeavor	Uses community involvement, cooperative groups, peer tutoring; multiple teachers as facilitators of learning
The learning connected to life, seasons, and environment	Investigates fundamental science questions of interest to students' everyday lives	Investigates questions related to life, seasons and the environment; considers multiple perspectives and disciplines
Students learn by watching, listening and doing; the Elder is expert	Practicing active and extended inquiry over time; use of print and electronic sources to help interpret or revise explanations	Learning is by active and extended inquiry; using multiple sources of expert knowledge including cultural experts
Teachings emphasize skills and practical application of the knowledge	The focus is on student understanding and the practical use of scientific knowledge, ideas or inquiry skills	Integrating skill development, understanding and application
The knowledge is shared through modeling, story-telling and innovation	The focus is on classroom communication and debate of understandings	Sharing diverse representations and communicating student ideas to both classmates and community

Conclusions and Limitations

In wrapping up this description around key ideas for decolonizing and/or decentring the current discourse on STEM and STEAM practices, I conclude by reiterating that the perspectives presented in my argument have leaned on the principles of biocultural diversity, Two-Eyed seeing and interdisciplinary forms of inquiry. All of these have important things to say about the types of pedagogy that are enacted in the realm of a more interdisciplinary or 'ecological' framework for science literacy.

First, the concept of bio-cultural diversity can be seen as dynamic as it takes the local values and practices of different cultural groups as its starting point. In working with Indigenous knowledge holders, the point is to work to preserve and restore important practices and values (for the benefit of all) but also to modify, adapt and create diversity in ways that resonate with both urban and rural school communities (Zandvliet et. al. 2023). In my opinion, bio-cultural diversity is a reflexive and sensitizing concept that can be used to assess the different values and knowledge of *all* people. As I have described in this paper, these concepts are closely tied to those of culture, and to teaching and learning.

Second, the evolving framework of *Two-Eyed Seeing* implies a co-learning journey as its pedagogy. In order to implement both knowledge systems, both educators and members of local First Nations communities need to walk and work together as they undertake the journey (Circony et. al. 2023). Given the place-specific nature of Indigenous knowledges, integrating First nations perspectives into classrooms also requires collaborating with local members of the community and alsoand focusing on meaningful cultural content. This involves positioning educators, students, and community as co-learners, sharing big ideas, and enacting project-based learning on issues of interest to both students and local communities. A co-learning journey also involves ongoing relationship-building, guided by the process of conversation. Only then do these connections have the potential to grow into long-term partnership between schools and local communities.

Third, interdisciplinary forms of inquiry may form a natural 'common ground' in bridging Indigenous and Western forms of knowledge-seeking and pedagogy. From a contemporary science perspective, a 5Es (representation-rich) approach can work to scaffold guided-inquiry by drawing on active knowledge construction methods that share common ground with traditional First Nations methods (Circony et al., 2023). Taking this idea further, other approaches have been recommended for enacting the 7Es model (FNESC, 2016), as activities often take place on the land (in Environment) and with Elders. In both examples of inquiry, the learning and assessment ideally take place at the same time with an emphasis on formative over summative approaches.

Finally, there are some important limitations to enacting the ideas summarised here. First, in considering diverse pedagogies, the design of curriculum is often seen as more or less *not* adaptable. School science has traditionally prescribed a single curriculum, irrespective of culture or place. In addition, science curricula are most often organised into disciplinary strands (biology, chemistry, earth sciences, physics, etc.), in an attempt to 'cover' a broad range of unrelated curricular topics (Schweingruber et al., 2012). Textbooks too, can tend to present a collection of information in the form of the "encyclopedic curriculum" in response to committee-influenced development teams (Schwartz et al., 2009, p. 799). Even today, textbooks often share science content that is considered by students as irrelevant to their everyday lives (Zidny et al., 2020). Even carefully designed experiments and other practical activities do not guarantee the meaningfulness of this type of activity when it is delivered in labs (Crawford, 2014). Nor do they work to enable students with the type of skills they will use to investigate topics in which are of natural interest to them.

In contrast to this limitation, Indigenous thought does not separate knowledge into disciplines (Battiste & Henderson, 2005). As one example, the Two-Eyed curriculum for the Integrative Science program at Cape Breton University went beyond the disciplinary siloes, instead following a transdisciplinary design that related to complex and socially relevant issues (Bartlett et al., 2012). Here, academic disciplines and traditional knowledge were puposelypurposely connected through the visual arts, and the body and mind through movement and dance. Further, both the content of curriculum and the forms of pedagogy used were strongly place-based, and followed a holistic education model that involved the integration of communities within the classroom (Hatcher et al., 2009).

Through the lenses of biocultural diversity, Two-Eyed seeing and interdisciplinary forms of inquiry, ultimately all students' learning can be connected with activities that are outside of school and 'in-community.' This is consistent with students' need to connect to the larger world of learning and understanding. Further, I believe that all students need to be purposefully connected to nature for these ideas to be effective. This can involve focusing on the senses and the powers of observation as important ways to help them re-establish themselves as 'part of nature,' a central concept within Indigenous perspectives. By designing our pedagogy and curriculum together in context, students can then develop an understanding that knowing is relational and dynamic. Only then can education '*get back to the real world'* and allow for creative approaches to science literacy, problem solving and cultural inquiry.

References

Aikenhead, G. & Elliott, D. (2010) An emerging decolonizing science education in Canada. *Canadian Journal of Science, Mathematics & Technology Education, 10*(4), 321–338. https://doi.org/10.1080/14926156.2010.524967

Alsop, J. Ormond, C.A., Wilson, B. & Zandvliet, D.B. (2023). Science and Story. *Cultural Studies in Science Education.*

Anderson, P. J., & Rhea, Z. M. (2018). Rights-based Indigenous education in Australia: Evidence-based policy to pedagogy. In M. Barnes, M. Gindidis, & S.Phillipson (Eds.), *Evidence-Based Learning and Teaching* (pp. 205–216). Routledge. https://doi.org/10.4324/9781351129367

Australian Institute for Teaching and School Leadership [AITSL]. (2022). *Australian professional standards for teachers*. https://www.aitsl.edu.au/docs/default-source/national-policy-framework/australian-professional-standards-for-teachers.pdf

Bang, M., & Medin, D. (2010). Cultural processes in science education: Supporting the navigation of multiple epistemologies. *Science education*, *94*(6), 1008-1026. https://doi.org/10.1002/sce.20392

Bartlett, C., Marshall, M., & Marshall, A. (2012). Two-Eyed seeing and other lessons learned within a co-learning journey of bringing together Indigenous and mainstream knowledges and ways of knowing. *Journal of Environmental Studies and Sciences, 2*(4), 331–340. https://doi.org/10.1007/s1341 2-012-0086-8

Battiste, M., & Henderson, J. Y. (2005). Protecting indigenous knowledge and heritage: A global challenge. In W. Caslin (Ed.), *Justice as healing: Indigenous ways* (pp. 240–244). Living Justice Press.

Berkes, F. (2017). *Sacred Ecology* (4th ed.). Routledge. https://doi.org/10.4324/9781315114644

Blackley, S., & Sheffield, R. (2015). Appraising the E in STEM education: Creative alternatives to 'Engineering'. *International Journal of Innovation in Science and Mathematics Education, 23(3*), 1–10. Retrieved from http://openjournals.library.usyd.edu.au/index.php/CAL/issue/view/791.

Burke, L.M., & Baker McNeill, J. (2011). 'Educate to innovate'. How the Obama plan for STEM education falls short. *Backgrounder, 2504,* 1–8.

Bybee, R.W., Taylor, J.A., Gardner, A., Van Scotter, P., Powell, J.C., Westbrook, A. & Landes, N. (2006). *The BSCS 5E Instructional Model: Origins, Effectiveness, and Applications*. https://bscs.org/wp-content/uploads/2022/01/bscs_5e_executive_summary-1.pdf

Cajete, G. A. (2000). *Indigenous science: Natural laws of independence*. Clearlight Publishers.

Chubb, I. (2015). *Aspiring to something magnificent*. Address to the National Press Club. Retrieved from http://www.chiefscientist.gov.au/2015/03/keynote-address-to-the-national-press-club-forsciencemeets-parliament-2/.

Cirkony, C., & Kenny, J. D. (2022). Using Formative Assessment to Build Coherence Between Educational Policy and Classroom Practice: A Case Study Using Inquiry in Science. *Australian Journal of Teacher Education, 47*(10, 77-105. http://dx.doi.org/10.14221/ajte.2022v47n10.5

Cirkony, C., Kenny, J. and Zandvliet, D. (2023). A Two-Eyed Seeing Teaching and Learning Framework for Science Education. *Canadian Journal of Science Mathematics and Technology Education.* https://doi.org/10.1007/s42330-023-00276-z

Crawford, B. A. (2014). From inquiry to scientific practices in the science classroom. In N.G. Lederman & S.K. Abell (Eds.), *Handbook of research on science education, Volume II* (pp. 529–556). Routledge. https://doi.org/10.4324/9780203097267

Deboer, G.E. (2006). Historical perspectives on inquiry teaching in schools. In: L.B. Flick & N.G. Lederman (Eds.), *Scientific inquiry and nature of science: Implications for teaching, learning, and teacher education* (pp. 17–35). Springer, Dordrecht. https://doi.org/10.1007/978-1-4020-5814-1_2

Dewey, J. (1910, 1990). Science as subject matter and as method. *Science, 31*(787), 121–127.

Donald, D. (2019). Homo-economicus and forgetful curriculum: Remembering other ways to be a human being. In, Tomlins-Jahnke, Huia, Styres, Sandra D., Lilley, Spencer, Zinga, Dawn. (Eds.) *Indigenous Education: New Directions in Theory and Practice*. University of Alberta Press.

Eberbach C., & Hmelo-Silver, C. (2015) Inquiry, Learning through. In: Gunstone R. (Ed.), *Encyclopedia of Science Education*. (pp. 514–517). Springer. https://doi.org/10.1007/978-94-007-2150-0_192

European Union. (2015). *Horizon 2020 Work Programme 2014-2015*. Retrieved from http://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/main/h2020-wp1415-leitict_v1.0_en.pdf.

First Nations Education Steering Committee [FNESC] (2016). *Science First Peoples teacher resource guide.* First Nations Education Steering Committee and First Nations Schools Association. http://www.fnesc.ca/wp/wp-content/uploads/2015/08/PUBLICATION-61496-Science-First-Peoples-2016-Full-F-WEB.pdf

Hackling, M., Murcia, K., West, J., & Anderson, K. (2014). *Optimising STEM education in WA schools Part 1: Summary report.* Perth, WA: Edith Cowan Institute for Education Research. Retrieved from http://www.tiac.wa.gov.au/Files/STEM_Report_Part-1_20022014.aspx.

Hall, L., Dell, C. A., Fornssler, B., Hopkins, C., Mushquash, C., & Rowan, M. (2015). Research as cultural renewal: Applying Two-Eyed seeing in a research project about cultural interventions in first nations addictions treatment. *International Indigenous Policy Journal, 6*(2), 1–15. https://doi.org/10.18584/iipj.2015.6.2.4

Harlen, W., & Bell, D. (2010). *Principles and big ideas of science education.* http://www.interacademies.net/File.aspx?id=25103

Hatcher, A., Bartlett, C., Marshall, A., & Marshall, M. (2009). Two-Eyed seeing in the classroom environment: Concepts, approaches, and challenges. *Canadian Journal of Science, Mathematics and Technology Education, 9*(3), 141–153. https://doi.org/10.1080/14926 150903118342

Iwama, M., Marshall, M., Marshall, A., & Bartlett, C. (2009). Two-Eyed seeing and the language of healing in community-based research. *Canadian Journal of Native Education*, *32*(2), 3–23.

Kenny, J. & Cirkony, C. (2018). Teaching using Student Generated Representations (SGRs) in science. In G. Woolcott & R. Whannell, R. (Eds.), *Science teaching theory and practice: Engaging with scientific thinking, problem solving and real-world contexts* (pp. 141–167). Cambridge Publications.

Kutz, S., & Tomaselli, M. (2019). "Two-Eyed seeing" supports wildlife health. *Science, 364*(6446), 1135–1137. https://doi.org/10.1126/science.aau6170

Levac, L., McMurtry, L., Stienstra, D., Baikie, G., Hanson, C., & Mucina, D. (2018). *Learning across Indigenous and Western knowledge systems and intersectionality: Reconciling social science research approaches*. Unpublished SSHRC Knowledge Synthesis Report. University of Guelph. https://www.criaw-icref.ca/wp-content/uploads/2021/04/Learning-Across-Indigenous-and-Western-KnowledgesFINAL.pdf

Lowan-Trudeau, G. (2013). Indigenous environmental education research in North America: A brief review. In R. B. Stevenson, M. Brody, J. Dillon, A. E. J. Wals (Eds), *International handbook of research on environmental education* (pp. 404-407). NY,NY: Routledge.

Maffi, L. (2007). Biocultural Diversity and Sustainability. In Pretty, J. Ball, A.S., Benton, T., Guivant, J.S., Lee, D.R., Orr, D., Pfeffer, M.J. and Ward, H. Pretty, J. Ball, A.S., Benton, T., Guivant, J.S., Lee, D.R., Orr, D., Pfeffer, M.J. and Ward, H. (Eds.) *Sage Handbook on Environment and Society*, 267–77. London: SAGE.

Michell, H. (2018). *Land-based education: Embracing the rhythms of the earth from an Indigenous perspective*. JCharlton Publishing.

Mistry, J., & Berardi, A. (2016). Bridging indigenous and scientific knowledge. *Science, 352*(6291), 1274–1275. https://www.science.org/doi/10.1126/science.aaf1160

National Research Council (2012). A framework for K-12 science education: Practices, crosscutting concepts, and core ideas. https://nap.nationalacademies.org/catalog/13165/a-framework-for-k-12-science-education-practices-crosscutting-concepts

Organisation for Economic Cooperation and Development (2020). *PISA 2024 Strategic vision and direction for science*. OECD Publishing. https://www.oecd.org/pisa/publications/PISA-2024-Science-Strategic-Vision-Proposal.pdf

Osborne, J., & Dillon, J. (2010). How science works: What is the nature of scientific reasoning and what do we know about student's understanding. In J. Osborne & J. Dillon (Eds.), *Good practice in science teaching: What research has to say* (pp. 20–46). Open University Press.

Reid, A. J., Eckert, L. E., Lane, J. F., Young, N., Hinch, S. G., Darimont, C. T., ... & Marshall, A. (2021). "Two-Eyed Seeing": An Indigenous framework to transform fisheries research and management. *Fish and Fisheries, 22*(2), 243–261.

Roher, S. I., Yu, Z., Martin, D. H., & Benoit, A. C. (2021). How is Etuaptmumk/Two-Eyed Seeing characterized in Indigenous health research? A scoping review. *PloS one*, *16*(7), e0254612. https://doi.org/10.1371/journal.pone.0254612

Roth, W-M., & Barton, A. (2004). *Rethinking Scientific Literacy*. Routledge Falmer. New York.

Sammel, A., & Zandvliet, D. (2003). Science reform or science conform: Problematic epistemological assumptions within Canadian science reform efforts. *Canadian Journal of Science, Mathematics, and Technology Education, 3(4),* 513–520.

Schwartz, M. S., Sadler, P. M., Sonnert, G., & Tai, R. H. (2009). Depth versus breadth: How content coverage in high school science courses relates to later success in college science coursework. *Science Education*, *93*(5), 798–826. https://doi.org/10.1002/sce.20328

Schweingruber, H., Keller, T., & Quinn, H. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. National Academies Press. https://nap.nationalacademies.org/catalog/13165/a-framework-for-k-12-science-education-practices-crosscutting-concepts

Smith, G.A., & Williams, D.R. (Eds.) (1999). *Ecological education in action: On weaving education, culture and the environment.* Albany, New York: State University of New York Press.

Snively, G., & Corsiglia, J. (2001). Discovering indigenous science: Implications for science education. *Science Education*, *85*(1), 6–34. https://doi.org/10.1002/1098-237X(200101)85:1<6::AID-SCE3>3.0.CO;2-R

Stephens, S. (2001). *Handbook for culturally responsive science curriculum*. Alaska: Alaska Native Knowledge Network. https://files.eric.ed.gov/fulltext/ED451986.pdf

Styres, S.D. (2011) Land as first teacher: a philosophical journeying, *Reflective Practice*, 12:6, 717-731, DOI: 10.1080/14623943.2011.601083

Swanton, J. R. (1905a). Contributions to the ethnology of the Haida. Memoirs of the *American Museum of Natural History Memoirs* 8(1). New York: G. E. Stechert

Swanton, J. R. (1905b). Haida texts and myths: Skidegate dialect. *Bureau of American Ethnology Bulletin*, No. 29. Washington, D.C.: Government Printing Office.

Tytler, R., Prain, V., Hubber, P., & Waldrip, B. (Eds.). (2013). *Constructing representations to learn in science*. Springer Science & Business Media.

United Nations General Assembly (2007). *United Nations Declaration on the Rights of Indigenous Peoples, A/RES/61/295*. http://www.unhcr.org/refwo rld/docid/ 47135 5a82.html

Wilson, B., & Harris, H. (2005). *Tllsda Xaaydas K'aayygang.nga*: Long, long ago Haida Stories. In D. W. Fedje & R. W. Mathewes (Eds.) *Haida Gwaii: Human history and environment from the Time of the Loon to the Time of the Iron People* (pp.121-139) Vancouver: UBC Press.

Zandvliet, D.; Leddy, S.; Inver, C.; Elderton, V.; Townrow, B.; York, L. (2023). Approaches to Bio-Cultural Diversity in British Columbia. *Sustainability*, 15(8), https://doi.org/10.3390/su15086422

Zandvliet, D.B. (2018). STEM and LEAF. *International Journal of Innovation in Science and Mathematics Education.*

Zandvliet, D.B. (2010). An Ecological Framework for Science Education. *Open Education Journal (3*). Retrieved from: http://benthamopen.com/contents/pdf/TOEDUJ/TOEDUJ-3-34.pdf

Zidny, R., Sjöström, J., & Eilks, I. (2020). A multi-perspective reflection on how indigenous knowledge and related ideas can improve science education for sustainability. *Science & Education, 29*(1), 145–185. https://doi.org/10.1007/s11191-019-0

A NOVEL PEDAGOGICAL TOOL FOR CHILDHOOD EDUCATION IN STEM AND STEAM TOWARDS ACHIEVING SUSTAINABLE DEVELOPMENT GOALS IN AFRICA

IBIYINKA OGUNLADE
Bamidele Olumila University of Science Education and Technology

Abstract

The integrating of Science, Technology, Engineering and Mathematics (STEM) and Science, Technology, Engineering, Art and Mathematics (STEAM) in Early Childhood Education in developing countries has proved to be a workable strategy in enhancing inclusive and equitable quality education and lifelong opportunities for all (SDG 4) towards achieving Sustainable Development Agenda by the year 2030.This paper presents a critical review of early childhood education in Africa, its impacts, benefits, challenges and plausible remedies. Theoretical frameworks in use were x-rayed with basic characteristics and types of pedagogical tools highlighted. A firsthand experience of non-formal, community-linked and integrated approaches, STEM Play cycle and Culturo-Techno-Contextual Approach (CTCA) to STEM and STEAM education at childhood stage was carried out in Ekiti State, a rural –urban setting in densely populated Nigeria for this case study research. The role of culture and influence of environment in learning were showcased.

Keywords: Children, Non-formal, STEM/STEAM, Education, Community

Introduction

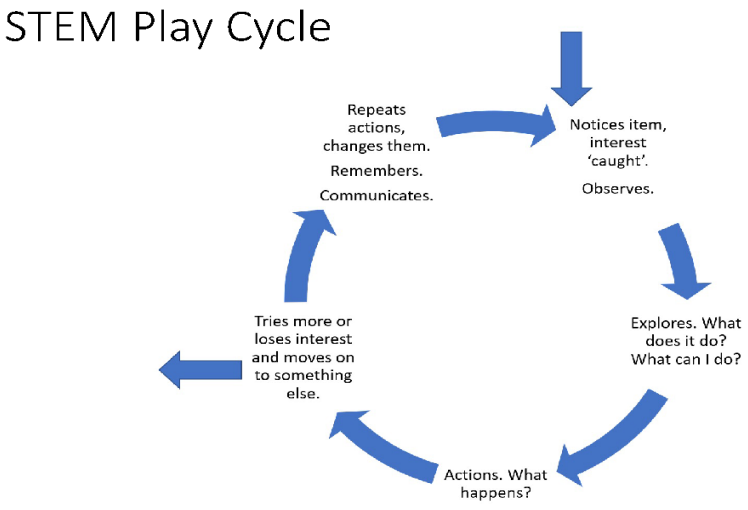
The success rate of achieving sustainable development goals is hinged on 'Ensuring inclusive and equitable quality education and promotes lifelong learning opportunities for All' (SDG 4) which can only be attained by innovative pedagogical methods of imparting knowledge in STEM and STEAM education at early years.

STEM (Science, Technology, Engineering and Mathematics) education can be developed at all stages of education, from pre-school to the tertiary levels given a favorable learning environment. The integration of Arts (STEAM) in STEM education brought about creativity, innovation, critical thinking, and problem-solving skills with the use of appropriate tools.

STEAM education seems potentially rich to foster creative and innovation in teaching and learning processes of education for sustainable national development. (Kim and Bolger2017). At the onset of STEM learning, home sets the pace for children early in life to be conscious of the activities within their surroundings, hence the need for innovative approaches and strategies to guide against ignorance, promote the culture of science and enable children to be interested in science and technology through a non-formal approach (Ogunlade, 2005) and STEM Play cycle (Tunnicliffe, 2021) for sustainable development. STEM Play cycle creates curiosity and develops skills for investigation and observation in children.

The STEM Play cycle starts with the interest of the children caught, followed by observations, explorations, actions, sustenance, and communication as shown in Figure 1.

Figure 1. *The STEM Play Cycle (Tunnicliffe,2021)*



STEM and STEAM education can be built by shifting the emphasis from rigid, formal methods of teaching to more interesting, creative, and innovative approaches to science teaching and learning processes that revolve round the day-to-day activities.

STEM and STEAM Education towards Sustainable Development

There is a direct correlation between STEM (Science, Technology, Engineering and Mathematics) and STEAM (Science, Technology, Engineering Arts and Mathematics) in Early Childhood Education; therefore, workable strategies need to be adopted to sustain children's interest for sustainable development. For example, a wide variety of activities that challenge children's thinking, observing, and generalizing using a non-formal approach supports STEM and STEAM learning such activities are revolving round home setting and schooling system that require mental functioning and encourage learning.

Outdoor learning and field trips that are centered on nature, animals, plants, seasons, and weather stimulate concept learning and integration of knowledge of the environment. Home Science include mothers-children's interactions, cooking projects as related to children's eating habits; Use of blocks as a medium for continuous learning; Water play in teaching STEM concepts of volume, measuring and numeracy numbers are of great benefit.

Early Childhood Education in Africa

Early Childhood Education (ECE) is a starting point for a child's development. It is taken as the key foundation of educational system in any country. (Obiweluozor, 2015). ECE is centred on the vital developmental platforms, abilities, and ideas that children pick up at this time in their lives, from social and emotional development to the emergence of reading, numeracy, and critical thinking.

Africa has a population of over one billion people and comprising of 54 countries but plagued with myriads of challenges, ranging from food insecurity, poverty, increasing population, impact of climate change and poor policy implementation (Hassan, 2023). Early childhood education plays an important role at the basic levels of learning in sciences and arts but unfortunately it is affected by socioeconomic challenges in Africa. Early childhood education which is the first tier of educational level (pre-primary schooling) is poorly developed despite its importance and significance in preparing children for conventional schooling. (Obiweluozor, 2015).

According to Curries (2001) and McCoy *et al* (2018), pre-primary development is significant and is a major contribution to school readiness of children, prevention of repetition and strengthening of school performance among children. The Organization for Economic Co-operation Development (OECD, 2006) considers the growth of high-quality Early Childhood Care and Education to be a crucial economic indicator for evaluating the health and future posture of a nation, in addition to preparing children for an all-round development. However, only 27% of children are reported to attend Early Childhood Education in Africa compared to 61% in another developed continent (Badiel, 2011). This accounts for a poor turnout in Early Childhood Education with resultant aggravated poverty.

Categories of Early Childhood Education in Africa

There are three categories of Early Childhood Education comprising of public, private and community services. These are usually established in cities, rural and remote areas. They are operated under different types of institutions such as Local, State and Federal within specified age range.

For community services, early childhood education is operated as Crèches (0-2years), Koranic schools, Community huts and pre- primary schools that are financed and managed by the national or international non- governmental organizations.

Pre- primary school and day-care centres do exist under the private services while the public services run day nurseries (3-6years) and Elementary classes (5-6years) managed by the Ministry of Education (Lawrence and Sharrock 2021).

Importance of Early Childhood Education in Africa

Education is one of the fundamental pillars as far as a country's developmental process is concerned; however, the lack of access to early education in Africa has affected the progress of African continent.

In Africa there are so many places where access to early childhood education is limited for the citizen due to poverty, corruption and bad leadership, the menace of poor education has contributed to the growth of violence, crime and unemployment In Africa there are so many places where access to early childhood education is limited for the citizen due to poverty, corruption and bad leadership, the menace of poor education has contributed to the growth of violence, crime and unemployment (Mellah *et al* 2022). Quality Early Childhood Education is one of the most powerful agents for change and sustainable development of a country, hence ECE aims to push, inspire, and nurture children during their early years which offer them the best opportunity for a healthy development.

Learning at the early stage positively influences the development of the cognitive, psychomotor, and affective domains in children. Furthermore, ECE lays the groundwork for continual cognitive development. According to a report by UNICEF (2019), 90% of children's brain develops before age 5.Learning cognitive and stimulation at this age help to provide solid foundation for other schooling activities and hence the belief that early childhood education will provide the needed human resources for future development (UNICEF, 2019).Recent studies have revealed that between birth and three years of age, the human brain generates most of its neurons and is most susceptible to learning. In fact, the development of active brain circuits depends on the assimilation of incoming information. (Shonkoff & Phillips, 2000). A child's physical, intellectual, emotional, and social development and the early years of life are critical because early learning occur between birth and age six along with the growth of mental and physical capacities.

Benefits of Early Childhood Education in Africa

The benefits of Early Childhood Education include:

1. Proved social skills through interactive play and communication with their school mate in a conductive pre -school play environment.
2. Eagerness to learn through exposure to novel/unconventional activities such as singing, play let rhymes.
3. Encouraging holistic development through building the child's cognitive, physical, social and emotion sufficient with counting and sorting (mathematics)
4. Boost self-confidence through interaction with other children and teachers displaying a level of boldness in articulation and positive mindset.
5. Enhanced attention span through painting, drawing, and playing with toys.

Challenges of Early Childhood Education in Africa

The extremely low rate of early childhood education in Africa where 1 in 4 children aged 3-5 attend some form of pre- school in Africa (Kabiru, 2017)are due to the following challenges: workplace burnout due to stress, staff shortage, low motivation for teachers and caregivers, inadequately trained teachers and caregivers, lack of learning materials, mental health concerns, lack of resources, safety issues, low level of compensation and ever-evolving technologies, lack of parental involvement, and lastly inadequate communication (Akinrotirni & Olowe, 2016). In addition, there are operational gaps in early childhood education centers due to lack of supervision and inspection of the pre-primary schools. Furthermore, there is no provision in teacher education programs for specialization in early childhood education and thereby the standard and quality of education are compromised.

Learning Barriers Confronting Early Childhood Education

There are some barriers confronting children learning in STEM and STEAM, these are cognitive, physical, mental, emotional, cultural, language, social and environmental as follows:

- ***Cognitive Learning Barrier (CLB):*** This limits the development and functions of children in social and practical skills that are needed in the classroom environment. Children's memory, problem solving skills, attention, reading, verbal, numerical and visual comprehension are affected.
- ***Emotional Learning Barrier (ELB):*** This is related to the emotions of children such as enjoyment, anger, fear, anxiety, boredom, pride, hope, or shame (Goetz & Perry, 2002). The most common emotional learning barriers occur due to peer pressure, fear of failure, judgment, rejection, emotional sensitivity, adjustment to change and embarrassment (Nash and Schlosser 2014).

- ***Environmental Learning Barrier (EnLB):*** These are the obstacles in the immediate surroundings of a child that can negatively influence their learning and behavior such as classroom management, size, time, space, resources available teacher- student ratio (DaRosa et al., 2011; Moore & Hansen, 2012). Environmental barriers could result in negative behavior, indifferences, lack of consecration in classroom discussion or weak connection between the student and teacher.
- ***Cultural Learning Barrier (CuLB):*** This barrier to learning occurs due to the influence of culture on children which in turn affects their perspectives to learning (Vulcan, 2018). According to Nunez *et al* (2017), the most common cultural barriers that can affect children are communication that is related to language, the meaning, interpretation of words, signs, and the motives of the conversation.
- ***Language Barriers (LB):*** Children facing language barriers are unable to have strong connection to the teacher, peers, community, and themselves. They find it difficult to freely express their thoughts, emotions, and feelings (Imberti, 2007).
- ***Mental Health Barriers (MB):*** Mental health barriers to learning STEM in children is their perception and coping threshold to stress, decision making, and capacity to participate with their family, community, and peers (Lean, Colucc & Fullan, 2010).
- ***Physical Learning Barriers (PLB):*** The physical learning barriers are visual and auditory impairments or speech and communication difficulties.
- ***Social Learning Barriers***: This is connected to the social development of children and the social skills that a child gains in STEM such as language, numerical skills, interpersonal skills, understanding of social cues and behaviors of others. Lack of development of social skills leads to lack of personal development that might result in learning difficulties in children (Damirchi, 2013)

Theoretical Frameworks

Over the years, there has been a variety of pedagogical tools in use to disseminate Science, Technology, Engineering and Mathematics (STEM) concepts. The onset and growing awareness of digital technological approach in teaching/learning process requires an emergence of innovative pedagogical tools such as non-formal approach (Ogunlade,2005), STEM play cycle (Tunicliffe,2021) and Culturo-Techno-Contextual Approach CTCA (Okebukola *et al*2022). Oladejo *et al* (2023) reported the efficacy of Culturo-Techno-Contextual Approach (CTCA) in reducing learning anxiety and promoting meaningful learning of chemistry among students.

This paper presents pedagogical tools for early childhood education in STEM and STEAM towards achieving Sustainable Development Goals through community- based approach, STEM Play cycle and using CTCA, as a method of learning by children at infancy. It was proposed that this may address challenges and barriers posed by traditional methods of integrating STEM and STEAM concepts in early years by their teachers. Incorporating STEM in early years through building blocks and identifying shapes has improved vocabularies, reading, numeracy and critical

thinking of children. STEM Play cycle creates curiosity and develops skills for investigation and observation in children as shown in Figures 2, 3, 4, 5 and 6.

Figure 2. *Children building blocks. Photo used with parental permission.*

Figure 3. *Children in critical thinking mode. Photo used with parental permission.*

Figure 4. *Children with investigation and observation skills in a home garden. Photo used with parental permission.*

Figure 5. *Culturo-Techno-Contextual approach to STEM. Photo used with parental permission.*

Figure 6. *Teaching /learning STEM using play cycle at a workshop. Photo used with parental permission.*

Non- Formal Approach to Teaching and Learning of STEM and STEAM Education

The conventional schooling system (formal approach) is not adequate for effective childhood education in STEM and STEAM, hence the need to complement it without -of- school activities (non-formal approach) especially for children. The diverse and dynamic nature of scientific knowledge poses several challenges as to the effective ways of disseminating its basic principles to learners especially of tender age. One non-formal approach for children is termed Children Science Clinic. Children Science Clinic is an annual workshop, aimed at getting children at tender age to learn and 'live' science. The motto of the project is "Catching them Young for Science". The 'Clinic' is intended to stimulate and create awareness in children in a world of growing scientific networks (Ogunlade, 1999).

This approach creates healthy scientific and technological cultures that influence education for entrepreneurship purposes. Children Science 'Clinic' with its novel approach and innovations affecting existing orientation, organizational structures, logistics and the inherent rigidities of formal educational systems in Nigeria.

According to Combs (1989), Non formal Education (NFE) is a bewildering variety of educational activities, consciously organized and operated outside the structure of the formal education system. They are generally free of rules, regulations, and conventions, designed to serve the interests and learning needs of children. To address children's education in the 21st century, Children Science Clinic adopts integrated programs in which learning of context with culture, evolving technology, and appropriate pedagogical tools to achieve broader developmental objectives of non-formal education. The goal of the program is to popularize Science and Technology among children and to enable them to play an active role in the process of development and acquire new knowledge to improve social and economic life of society.

Pedagogy As a Tool for STEM And STEAM Education

Pedagogy is the method and practice of teaching, especially in relation to academic subjects or theoretical concepts (Li, G., 2012). Pedagogy can refer to all levels of teaching from pre-primary, nursery and primary to higher education. it is the relationship between learning techniques and culture. This factor puts emphasis upon the point that pedagogy contributes in an efficient manner in enriching the culture of the educational institutions at all levels. It is determined through the norms and beliefs of the educators regarding how learning should take place. The procedures need to be effectual, meaningful, and worthwhile. The strategies that are put into operation should render a significant contribution in facilitating the achievement of academic goals (Johnson *et al* 2014). Pedagogical tools encourage teamwork for children to develop mutual understanding and work in co-ordination and integration with each other through significant learning strategies.

Pedagogical Approaches

There are 5 different Pedagogical approaches, these are:

1. ***Constructivist Approach:*** The constructivist approach is based on the concept of learners creating their own understanding of the world around them and this understanding is based on the experiences through their everyday lives as they grow (Pritchard and Woollard, 2012). This approach is handy for allowing learners to take a more active role in the learning process as it encourages them to use their previous knowledge as a foundation for understanding new concepts as opposed to passively receiving information.
2. ***Collaborative Approach****:* The collaborative approach is the idea that learners work together to gain a greater understanding of the information. The strength of this approach is that learners can capitalize on each other's understanding of the information, and even their unique skills and resources (Laal and Laal, 2012). This process allows for learners to create an environment where people can interact with each other by sharing experiences and knowledge. This can be done in a variety of ways, including exchanging ideas and information, evaluating, or monitoring somebody else's work.
3. ***Reflective Approach***: The reflective approach focuses primarily on analyzing what the teacher and learners are doing in the classroom. It encourages thinking about teaching practices and figuring out ways to improve them to make learning processes more effective for learners. This can be done through processes such as self-evaluation and self-reflection.
4. ***Integrative Approach:*** The integrative approach differs from the other teaching approaches in the sense that it tries to provide learners with an environment where they can make connections between the current topic they are learning about and other topics they will come across at different stages of the curriculum (Roegiers, 2016). This means that it tends to focus on specific connections between different bits of information rather than facts in isolation. While this approach is more commonly used in higher education,

it can still be quite useful at other stages of education too as it can help learners gain a broader understanding of the world around them by linking together bits of related information. Studies have shown that this kind of approach can help learners stay engaged on the topics they are learning about.

5. ***Inquiry-based Approach:*** The inquiry-based approach is a unique approach of encouraging learners to engage in exploration, investigation, research, and study (Rabih, 2007). It begins with presenting questions, scenarios or problems that require critical thinking to solve problems, which is vastly different from other approaches where facts are presented in a simple manner. This approach requires more than just simply giving the correct answers to questions and encourages more thoughtful and engaged participation from learners (Pedasta *et al, 2017)*. This makes it incredibly effective when teaching science, as many science topics are more easily learned through an understanding of processes rather than isolated facts.

Table 1. Process skills used in STEM/STEAM science activities by children.

Circus Items / Process Skills	1	2	3	4
Raising Questions	Children Interaction Plants & Animal Kingdom.	Health time ABC of Dental Hygiene.	Science Essay Competition. Science has done better to man than art.	My rights as a road user.
Prediction	The language of Science is Mathematics.	Science puzzle.	Science Career Compass.	Weather Control.
Observing	One world in danger.	Weather Observations.	Use of the System (Eye watch).	Classification of plants and Animal Kingdom.
Hypothesizing	Paper Pencil Activity.	Group activities.	The world around us.	Composition of water.
Measuring and Calculating	Reality of Mathematics.	Weather Recording.	Nutritional Assessment.	Buying and Selling in the market**.**

Manipulating Materials	Conversion and Transfer of Energy.	Excursion to Science based Industries.	My little world of computer.	I belong to Computer age.
Devising and Planning	Air has weight.	Science games e.g., snakes & ladder.	Causes and Prevention of fire.	Prevention is better than cure Malaria, HIV/AIDS.
Designing and Making	Take home project e.g First Aid box.	Making a telephone, Stethoscope etc.	Conditions Necessary for seed germination.	Science is Photographic.
Communicating	The reality of Mathematics to children Areas of plane geometry. Triangle, Rectangle.	Mind your language even in Science.	The language of Science is Mathematics.	Telecommunication, keeping your messages secret.
Finding patterns relationships	Take trip round the world in 30 mins.	Science Crossword puzzle.	Food square.	Blood types & Groups.

Conclusion and Recommendations

Developing countries are striving to come up with newer techniques suitable for their environment and culture to attain the target of SDGs, thereby creating a platform for teaching and learning process of STEM and STEAM education. In this 21st century learners need to acquire strong STEM/STEAM abilities to be competitive at work and in the environment. Thus, development of profound knowledge and skill sets in teamwork, rational thinking, investigative and creative work in all areas of life is essential. The development of STEM in Nigeria has been able to shift the emphasis from a rigid, formal method of teaching to a more interesting inquiry-based, community-integrated approach to science teaching and learning process which revolves around the day-to-day activities of the people. Integrating STEM and STEAM concepts in early years will awaken the hidden potentials of the young children thereby providing them with an exciting avenue to explore, ask questions, and observe activities. An environment where the educators and children are free to express themselves was created. In addition, the environment should include outdoor spaces for early childhood education where children can embark on active inquiry, investigation

and problem-solving which can help teaching and learning of STEM and STEAM concepts. Finally, this paper recommends capacity training workshops, funding, effective monitoring and evaluation processes, and support for the well-being of early childhood educators.

References

Comber, B. (2011). Making Space for Place-making Pedagogies, Stretching the Normative mandated literacy curriculum: Contemporary Issues in Early Childhood, 12(4):343-348. https:// doi.org/10.2304/ciec.2011 12.4.343.

Combs, Arthur W.A (1989) New Assumptions for Teacher Education. Journal of Computer Assisted Learning. https:// doi.org/10.1111/j.1944-9720.1989.tb01971.x.

Cottone, E. (2012). Preschoolers' Emergent Literacy Skills: The Mediating Role of Maternal Reading Beliefs Early Education and Development Volume 23, 351-372 https://doi.org/10.1080/10409289.2010.527581

Dahlberg, G., Moss, P. & Pence, A. 1999. Beyond Quality in Early Childhood Education. London: Falmer. https:// doi.org/10.1080/10409289 2010. 5277581

Currie, Janet. (2001). "Early Childhood Education Programs." *Journal of Economic Perspectives*, 15 (2): 213-238.dOI: 10.1257/jep.15.2.213.

DaRosa DA, Skeff K, Friedland J.A, Coburn M, Cox S, Pollart S, O 'connell M, &Smith S. (2011). Barriers to Effective Teaching. Acad Med. http://Journals.lww.com/Academicmedicine/Fulltext/2004/08000/The_Academy_Movement__A_ Structural_Approach_Doi.10.1097/ACM.0b013e31820defbe.PMID :21346500.

Mellah E.U, Charles E. & Maria-Assumpta O. A. (2022). EARLY Childhood Care Education, Good Governance and Challenges of Insecurity in Nigeria. Multidisciplinary Journal of Research Development, Volume 31 No 1, March, 2022 -ISSN 1596-974X.

Damirchi E. S. *(2013).* The Impact of Social-Emotional Learning Skills Programs on Social Development Among Primary School Students. Journal of Education and Practice www.iiste.org ISSN 2222-1735 (Paper) ISSN 2222-288X (Online Vol.4, No.16, 2013 https://doi.org/10.7176/JEP

Ibukunolu Adebiyi Ademola*, Adekunle Ibrahim Oladejo, Olasunkanmi Adio Gbeleyi, Franklin Ufoma Onowugbeda, Olatunde Lawal Owolabi, Peter Akinsola Okebukola, Deborah Oluwatosin Agbanimu, &Stella Ihuoma Uhuegbu(2023). Impact of Culturo-Techno-Contextual Approach (CTCA) on Learning Retention: A Study on Nuclear Chemistry.Journal of Chemical Education. https://doi.org/10.1021/acs.jchemed.2c00661

Dermitzaki, I. Leondari, A. & Goudas, M. (2009). Relation Between Young Students' Strategic Behaviors, Domain – Specific Self-Concept, and Performance in A Problem – Solving Situation, Learning and Instruction, 19,144-157

Imberti, P. (*2007*). Who Resides Behind the Words? Exploring and Understanding the Language Experience of The Non-English-Speaking Immigrant ...*Families in Society, 88*(1), 67–73. https://doi.org/10.1606/1044-3894.3593

Gorey K. M. (2001). Early Childhood Education: A Meta-Analytic Affirmation of the Short and Long-Term Benefits of Educational Opportunity. *School Psychology Quarterly*, 16(1), 9–30. https://doi.org/10.1521/scpq.16.1.9.19163.

Munum Hassan, (2023). Mean Temperature and Drought Projections in Central Africa: A Population-Based Study of Food Insecurity, Childhood Malnutrition and Mortality, and Infectious Disease. doi: 10.3390/ijerph20032697.

Johnson, D. W., Johnson, R. T., & Smith, K. A. (2014). Cooperative Learning: Improving University Instruction By Basing Practice On Validated Theory. *Journal On Excellence in College Teaching*, 25(3&4), 85-118.

Kim, D., & Bolger, M. (2017). Analysis of Korean Elementary Pre-Service Teachers' Changing Attitudes About Integrated STEAM Pedagogy Through Developing Lesson Plans. International Journal of Science and Mathematics Education, 15(4), 587–605. https://doi.org/10.1007/s10763-015-9709-3

Laal, M. & Laal, M. (2012). Collaborative Learning: What Is It? *Procedia: Social and Behavioral Sciences*, 31, 491-495. *American Journal of Educational Research*. **2021**, Vol. 9 No. 12, 701-707 **DOI:** 10.12691/education-9-12-2.

Lawrence, B.J., & Sharrock, E. (2021). Establishing Early Care and Education as a Public Good. http://educate.bankstreet.edu/bsuec.

Maduewesi, E.L. (1992). Implementation of Educational Policy in Pre-Primary and Primary Education: Achievements and Short Comings, in A. Ndu (Ed.) *Educational policy and implementation in Nigeria*. Awka: Mekslink Publishers.

McCoy, D. C., Yoshikawa, H., Ziol-Guest, K. M., Duncan, G. J., Schindler, H. S., Magnuson, K., Yang, R., Koepp, A., & Shonkoff, J. P. (2017). Impacts of Early Childhood Education on Medium- and Long-Term Educational Outcomes. *Educational Researcher*, *46*(8), 474-487. https://doi.org/10.3102/0013189X17737739.

Nash, P., & Schlösser, A. (2014). Working with schools in identifying and overcoming emotional barriers to learning. *Educational Studies*, *41*(1-2), 143-155. [Special Issue]. https://doi.org/10.1080/03055698.2014.955738.

Nkechi Obiweluozor (2015). Early Childhood Education In Nigeria, Policy Implementation: Critique And A Way Forward African Journal Of Teacher Education. Doi: 10.21083/Ajote.V4i1.2930.

Ogunlade, Y (2005): Non-formal Approach to the Popularization of Science and Technology Education to Children in the 21st century. International Journal of Children-in-Science and Technology Vol 3 No 2.pp146-150.

Margus Pedaste, Mario Maeots, Leo A. Siiman, Ton de Jong, Siswa A. N. Van Riesen, Ellen T.

Kamp, Constantinos C. Manoli, & Zacharias C. Z. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. https://doi.org/10.1016/j.edurev.2015.02.003

Pekrun, R., Goetz, T., Titz, W., & Perry, R. P. (2002). Academic Emotions in Students' Self-Regulated Learning and Achievement: A Program Of Qualitative And Quantitative *Research. Educational Psychologist,37(2),91105.* https://doi.org/10.1207/S15326985EP3702_4.

Rabih J. N. (2107). Integration of Inquiry-Based Learning and Ongoing Assessment to Develop English Essay Writing in Upper Intermediate Level . Journal of Modern Linguistics, Vol.7 No.2, DOI: 10.4236/ojml.2017.72008.

Roegiers, X. (2016) A Conceptual Framework for Competencies Assessment. UNESCO International Bureau of Education https://unesdoc.unesco.org/ark:/48223/pf0000245195

Shager H. M., Schindler H. S., Magnuson K. A., Duncan G. J., Yoshikawa H., &

Hart C. M. (2013). Can Research Design Explain Variation in Head Start Research Results? A Meta-Analysis of Cognitive and Achievement Outcomes. *Educational Evaluation and Policy Analysis*, 35(1), 76–95. https://doi.org/10.1146/annurev-publhealth-071321-032337.

Shonkoff J. P., & Phillips D. A. (Eds.). (2000). *From Neurons to Neighborhoods: The Science of Early Childhood Development*. Washington, DC: National Academies Press.
Akinrotimi , A & Olowe P (2016). Challenges in Implementation of Early Childhood Education in Nigeria the Way Forward. org ISSN 2222-1735 (paper) ISSN 2222-288X (online) Vol. 7, NO 7 2016.

Barratt-Pugh, C. (2000). The Socio-Cultural Context of Literacy Learning. In: C. Barratt- Pugh & M. Rohi (Eds). Literacy Learning in The Early Years. Crows Nest, NSW: Allen & Unwin. 1-26.

Li, G., 2012. Culturally Contested Pedagogy: Battles of Literacy and Schooling Between Mainstream Teachers and Asian Immigrant Parents. Suny Press.

Moore, K.D. and Hansen, J. 2012. Effective Strategies for Teaching in k-8 Classrooms thousand Oaks, CA:

Okebukola Peter A. (2020) Breaking Barriers to Meaningful Learning Using Culturo Techno- Contextual-Approach (CTCA) published by Sterling publishers, Slough, UK and Delhi, India. ISBN:978-81-944007-4-5

Pino Pasternak, D., Valcan, D., &Malpique, A. (2019). Associations Between the Home Environment, Parenting and Self-Regulation in Early Childhood. In D. Whitebread, V. Grau, K. Kumpulainen, M. McClelland, N. Perry, & D. Pino-Pasternak (Eds.), *The SAGE Handbook of Developmental Psychology and Early Childhood Education* (1 ed., pp. 487-501).

Pritchard, Alan & Woollard, John (2010). Psychology for the Classroom: Constructivism and Social Learning. Routledge 270 Madison Avenue, New York, NY10016.

Tunniciffe,S.D (2021):Talk And Do Science At Home. Talk given at Professional Development Institute Jamaica Early Childhood Directorate Ministry of Education Government of Jamaica.

Federal Republic of Nigeria (2012). National Policy on Education (4th). Lagos NERCDC.

Auguste Badiel (2011). Orphan Life Foundation (Non-profit organization).

David Kabiru (2017). Early Childhood Development, Their world. URL: https://theirworld.org/news/day-of-african-child-lack-of-crucial-early-childhood-education-pre-primary/

*UNICEF's (*2019). First Global Report on Pre-Primary Education Presents a Comprehensive Analysis of the Status of *Early Childhood Education* Worldwide.

STEAM AND ENGLISH FOR SPECIFIC PURPOSES: ONLINE COURSES FOR BRAZILIAN STUDENTS IN TECHNOLOGY

MARIANA BACKES NUNES
PATRÍCIA DA SILVA CAMPELO COSTA BARCELLOS
Universidade Federal do Rio Grande do Sul (UFRGS)

Abstract[1]

Nowadays, we have an increase in informal online courses in Brazil with a variety of subjects, according to the students' needs and interests. These informal courses could complement the knowledge learned in schools and universities, associating formal and informal learning, as defended by the Education 4.0 model. Additional languages, especially the English language, represent a great part of these courses as our society now understands the importance of English in a digital and technological world. English for Specific Purposes (ESP) is an area of English teaching-learning that takes into consideration the student's needs in the curriculum design, focusing on a context where learners will use the language in real life. This area is also interdisciplinary because it connects linguistic structures with professional fields. For this reason, STEAM (Science, Technology, Engineering, Arts, and Mathematics) education could be an interesting approach in ESP courses by providing an integrative method. Thus, this paper aims to analyze three informal online English courses designed for Brazilian students/professionals in technology considering the ESP and STEAM approaches and compare them with university learners' needs. After the analysis, we understand in this paper that informal English courses, particularly ESP ones, should be designed by an interdisciplinary group of professionals, such as language teachers and specialists in the area, in order to show a meaningful learning experience. Besides, it is important to go beyond a list of vocabulary, integrating the four language skills and working with genres connected to the students' own areas of study.

Keywords: English for Specific Purposes, STEAM, Online Courses.

[1] This paper is part of the first author's dissertation in the Doctoral Degree Program of Computing in Education at Universidade Federal do Rio Grande do Sul (UFRGS), with the second author as the advisor.

Introduction

In the last years, we have seen an increase in online courses in Brazil, especially during the COVID-19 pandemic, when people tried new modalities of learning and not only face-to-face classes as they were used to (Painel TIC Covid-19, 2020). Flexibility and autonomy are two aspects that called the attention of students to online courses, saving them time by offering them the option to study at their own pace and anywhere they go. With a variety of subjects, nowadays students can also choose a course according to their interests and needs and study them through their computers or even smartphones.

English as an additional language is a significant part of these online courses since this knowledge became a required skill to live in a contemporary world where most of our technologies are planned and organized in English. Digital skills and the English language are now essential cultural capitals that can help us be part of a multicultural and digital ubiquitous society (Finardi, Prebianca & Monn, 2013). By using digital technologies in the English learning process, we have more contact with the language in use as well as a real audience to interact with, not to mention the number of authentic materials that we could have access through the internet to improve our reading and listening skills.

Thus, it is crucial to address an education that faces the challenges of a future still to be created. STEAM - Science, Technology, Engineering, Arts, and Mathematics - approach, for example, discusses some concepts that will be important through this journey, such as the digitalization of education, the integration of formal and informal learning, interdisciplinarity and creative spaces among others (Shatunova, Anisimova, Sabirova & Kalimullina, 2019). However, the most important part of STEAM education is to create meaningful learning by connecting the content studied in class to real-life situations beyond the school walls.

English for Specific Purposes (ESP) is an area that already includes an interdisciplinary approach and focuses on the student's realities in order to create contextualized learning (Araki, 2013; Uliana, 2017). Today informal online English courses aimed at specific groups of professionals are more common because they offer a product that is relevant to their careers: it is the knowledge contextualized - as advocated by the STEAM and ESP approaches.

Therefore, this paper aims to analyze three informal online English courses in Brazil designed for professionals/students in technology, considering the ESP and STEAM approaches. It has also an interest in understanding how these courses are organized and how they manage the interdisciplinary and integrative methodology that should be present in an ESP context.

STEAM and English for Specific Purposes

STEM education is a pedagogy created in 2007, during the Americans for the Arts-National Policy Roundtable discussion, in order to increase students' interest, especially some minority groups, in Science, Technology, Engineering, and Mathematics fields (Perignat & Katz-Buonincontro, 2019). The A for Arts was added lately to the acronym with the aim to integrate creativity, problem-solving, and humanities in general into technical knowledge (Shatunova et al, 2019).

There are different definitions for STEAM in literature. In this study, we understand STEAM as an integrative approach in education that merges different areas of knowledge in an interdisciplinary, or even transdisciplinary way (Perignat & Katz-Buonincontro, 2019; Shatunova et al, 2019). STEAM is also an applied approach since it connects education with professional growth considering that its focus is on the knowledge learned in context. Thus, STEAM can be a helpful pedagogy to build problem-solving skills and to challenge students to make connections between what is learned in class and the situations of the real world.

In the STEAM approach, there are five steps to follow during a project: observing, asking questions, making predictions, experimenting, and discussing (Miralimovna, 2022). Through these stages, the students focus on a subject, research and observe this subject in their realities, find possible questions or gaps that go beyond this field, make predictions about what they are going to discover, experiment by applying the knowledge they have learned so far in a context, and, finally, discuss the results with peers. In this pedagogy, the learning process becomes more flexible and meaningful, and the student is at its center.

Therefore, the English for Specific Purposes (ESP) area can be linked to the STEAM approach. ESP has been used since the 70s in Brazil to describe English learning and its focus on a specific context in which the language appears. Celani (2009) highlights that the ESP's special dedication is making its students see meaning in language learning in their most practical everyday life. Usually, ESP is divided into two subareas: English for Academic Purposes and English for Occupational Purposes, depending on the students' interests and needs.

As in the STEAM approach observing and asking questions are the two first steps, the needs analysis is the first stage of ESP since it is a moment to identify students' prior knowledge and future needs. According to Araki (2013), ESP's differential is mainly the awareness of students and teachers about the present needs and gaps - a fact that in many teaching levels ends up not happening. The analysis of students' needs through a questionnaire, or an interview is essential for the teacher to establish the objectives and purposes of the course in adapting the curriculum to its students (Irshard & Anwar, 2018).

Dudley Evans and St. John (1998) postulate that certain aspects should gain importance in this phase of the investigation, such as needs related to language, the students' interests in the course, the gaps presented, information regarding specific situations in the area studied, prior

knowledge of students, and students' personal and professional information. Meanwhile, Hutchinson and Waters (2006) summarize that this analysis identifies not only the needs but the gaps and interests of the target audience. Also, it is equally important to seek the opinion of specialists in the area about the contents addressed in the course (Oliveira & Cooper, 2018).

Another link between STEAM and ESP is the interdisciplinary approach. In an ESP course, it is important to mobilize not only language content but the knowledge from the students' professional or academic fields. ESP is centered on language, skills, discourse, and appropriate genres for the activities that the professional will face in the future (Araki, 2013). In the area of technology, for example, where the English language has a high degree of importance, the student/future professional must be able to read and understand manuals, carry out warning messages, understand complex texts about basic computing, and present projects among other activities.

Currently, in Brazil, many ESP courses focus on learning mainly reading strategies, technical vocabulary, and basic notions of text production. This format is wrongly called by many as Instrumental English. Celani (2009) explains that it is a myth to believe that Instrumental English or ESP is synonymous with teaching only reading or technical vocabulary in the area. For a professional already placed in some way in the field, the technical vocabulary itself is not his biggest challenge (Araki, 2013). Thus, it is important that the learning process goes beyond these topics, integrating the four language skills (reading, writing, listening, and speaking) and presenting them in a contextualized way in the area for which the course is aimed (Uliana, 2017). We need to expand the ESP study to discursive genres (Hyon, 2018), and, from them, work on aspects such as vocabulary, grammar, etc.

The material provided in an ESP class should also be as authentic as possible to the context so the content and experience make sense to the student (Jonhs & Salmani Nobouchan, 2015). One good example of this aspect is the decision made by the Brazilian National ESP Project, coordinated by Celani (2009) at PUCSP University, to not adopt or produce a specific textbook. In this way, it can guarantee the recognition of diversity and local cultures in each ESP course. Therefore, it is important to analyze different contexts of ESP, like the technology field, to understand how they work and how can they learn from the STEAM approach.

Online English courses in Brazil

We have seen an increase in the offer of online courses in Brazil in recent decades, mainly in Higher Education. They arise with the aim of facilitating access to study by adjusting the pace to the student's individual routine. There is no consensual definition of Distance Education in the literature, but most researchers highlight the physical separation between teacher and student and the use of means of communication as mediators of the teaching and learning processes (Barin & Bastos, 2014; Fernandes, Henn & Kist, 2020).

Behar (2009) defines Distance Education as a new pedagogical space characterized by the development of skills and abilities, respect for the student's individual pace, the formation of learning communities, and the creation of coexistence of networks. Distance Education requires a different teaching model since it is not just a mere transposition of the methodology used in face-to-face classrooms. It is important, for example, to discuss previously how the content will be presented to the student, how the evaluation will be done, and how feedback will be given. In this modality, the teacher is responsible for helping create an online community among the students and mediate learning through the materials chosen. On the other hand, the student has greater autonomy and is responsible for his/her own study, which requires discipline and good study strategies (Behar, 2009; Fernandes et al, 2020).

In the same way, informal online courses have also expanded. The number of students in informal online courses today almost triples the number of formal ones, being one of the main vehicles for informal learning (Araújo et al., 2019). The subjects offered are generally related to the personal interests of the students and provide opportunities for learning in different domains due to the fact that the internet provides a range of possibilities, from everyday knowledge to scientific knowledge (Viana, Costa & Peralta, 2017).

Informal online courses are usually characterized by little or no formalization of teaching, that is, they do not stipulate a structure that the student must follow. The student often organizes his/her study to achieve his/her personal purposes with the course. The learner also does not keep his/her learning only based on the course, rather they search for different materials, such as papers, websites, discussion forums, podcasts, etc, to improve his/her learning (Viana et al, 2017)

Puncreobutr (2016), when describing Education 4.01F[2], mentions the importance of informal contexts of learning and how they should be recognized more by universities. According to the author, the university itself cannot provide an integrative education without opening its doors to the real world and its needs. We live in a technological era, and we must be prepared for a future that still does not exist. Informal courses together with academic education can help students become updated and problem-solving future professionals, which the STEAM approach also advocates.

According to the Painel TIC COVID-19 (2020), during the pandemic, there was an increase in Brazil in students over 16 years old subscribing to online courses, formal or informal ones. 40% of these students who studied online were enrolled in an additional language online course, especially focused on the English language. This number shows the importance given nowadays to additional language learning and how the English language became a fundamental knowledge to survive in a technological world.

[2] An education model urged by the needs of Industry 4.0, which provides for teaching-learning a focus on learning by doing and experimentation in the context of Web 4.0.

Methodology

The methodology applied in this study is qualitative, based on a case study. The case study is an interdisciplinary method used to understand a phenomenon in its context. It is situated in qualitative research because it has an interpretative and descriptive aspect when investigating the phenomenon in its natural environment, focusing mainly on its process. In addition, it takes into account the interpretation of the phenomenon by the subjects involved in it (Yin, 2014; Stake 1999).

The case study is then used to understand complex social phenomena from a holistic perspective (Yin, 2014) by seeing the case as an integrated system and seeking to understand it in its entirety (Stake, 1999). For this purpose, different forms of data collection are used, which, in the end, will be interpreted and analyzed by the researchers.

Since this paper aims to analyze informal online English courses for Brazilian students/professionals in the technology area, the research carried out was divided into two moments, following the steps of STEAM - observing, asking questions, making predictions, experimenting, and discussing. In the first moment, a needs analysis questionnaire was distributed through *Google Forms* to 24 students of Software Engineering from a federal university in Brazil[3]. The questionnaire had a total of 12 questions and sought to verify the point of view of the students about the area of technology regarding the use of the English language in their future careers. The second moment was an analysis of three informal online English courses for Brazilian students/professionals in technology. This analysis had the objective of comparing the needs in this field and the course's purposes.

Needs analyses with university students in the area of technology

The questionnaire applied to the students was based on the models of Neves (2019) and Monteiro and Bezerra (2012). It had the objective of identifying the profile of the students, their motivation for the chosen profession, their skills in the additional language, and their perception of the importance of the English language for their careers.

In general, the students mentioned having studied English before Higher Education, especially during High School (22). Some have also studied in private courses (12) and even online courses (7), including a great number of students who have learned English by themselves (18). However, the participants considered their English knowledge more advanced in reading and listening skills, and more at a beginner level when considering the production skills, like writing and speaking.

[3] This research was approved by the Research Ethics Committee of Universidade Federal do Rio Grande do Sul (CEP/UFRGS) by the CAAE number 63440822.5.0000.5347.

When asked what the reasons were for choosing the technology area as a career, the students described "*the broad job market*" or "*the many opportunities with which I have an affinity*" related to the job. Also, the desire of working abroad and/or having a good salary was also a factor behind the choice. These answers show that the students are thinking and planning their own future after university - and one student is already working in the field.

The students can identify the importance of the English language as well to their future professional life. They believe that "*English is crucial since most programming languages and development standards are based on the English language (...) and most of the documentation and study materials are in English.*" Then, they made a list of possible tasks that their future career could require in terms of English usage: being part of meetings, writing code (naming variables), reading documentation, communicating with vendors and partners, and participating in forums are some examples.

In this questionnaire, there was a comment made by one student that is important to be discussed here: *"In our university, we had Instrumental English, but the course approached words or situations that would not necessarily help us in the performance of functions in our area, again approaching basic high school things or even much lower levels, or common words, such as 'hardware' and 'software'".* His comment confirms some issues that other authors criticize (e.g., Celani, 2009) about most ESP courses: the strong focus on reading activities and basic vocabulary lists, without consulting the students' real needs.

Therefore, in this paper, we selected three informal English courses aimed at Brazilian students in technology to analyze their structures and purposes considering the ESP and STEAM approach. Additionally, this study has the objective of analyzing the requirements pointed out in the needs analysis into the courses to see if they attend them.

Analysis of informal online English courses aimed at the area of technology

There are few offerings of informal online English courses for students/professionals in the technology area in Brazil. Generally, they are developed by smaller companies and hosted on third-party online course platforms, like *Hotmart* or *Udemy.* Here we selected three online courses to analyze with the data collected in the year 2022. The courses are analyzed according to the following criteria: who created or is promoting the course, its slogan, its idea of the language learning process, the investment needed, the course structure, and its virtual learning environment. The courses are described below:

Table 1. Analysis of informal online English courses in Brazil aimed at the area of technology.

BEILS - INGLÊS TÉCNICO PARA T.I.	
Created by	Beils - Escolas de Inglês (part of the group Burlington English)
Slogan	"Be a reference in your professional area"
Idea of the language learning process	It emphasizes the use of language in a specific context, the IT area, despite presenting it as very general knowledge. It also has a greater focus on comprehension skills and written production and specific vocabulary of technical texts. It also reinforces the myth of the native speaker by stating that it takes confidence to talk with a native speaker.
Investment	The course does not display this information on the homepage of the website.
Course structure	Online or hybrid course, aimed at the following professions: computer technicians, developers, graphic designers, automotive sector, and network administrators. In its structure, some subjects addressed are: writing reports in English; defending professional arguments in English; studying technical expressions used in the job routine.
Virtual learning environment	It uses the school platform: https://beils.com/br/carreiras/ciencias-e-tecnologia/
Extra information	The language school offers English courses for other professional areas, such as business, law, finance, medicine, and travel.
CURSO DE INGLÊS PARA TECNOLOGIA DA INFORMAÇÃO	
Created by	Giorgi Bastos (Graduated in Publicity and Propaganda and post-graduated in Software Engineering / he has 30 years of experience with the English language).
Slogan	"IT professionals with fluent English have more chances in the market and can earn salaries of up to 5 figures."
Idea of the language learning process	It emphasizes the use of the language in a specific context, the IT area. It also has a greater focus on conversation, not on reading or writing skills. It follows what they call "accelerated learning techniques and non-linear methodology to enable IT professionals to communicate satisfactorily within their professional context, with self-confidence and ease".

Investment	BRL 34.90. Full lifetime access.
Course structure	The course is aimed at the following professions: Web Developers; Artificial Intelligence and IoT professionals; Database Analysts; DevOps professionals; Information Security Professionals; Software Engineers and Architects; Network Architects and Engineers; Business Intelligence professionals; Digital Marketing Professionals; and Game Developers. Therefore, the course is based on the real day-to-day experiences of these professionals. It is composed of 9 hours of videos, 4 articles, and 48 downloadable resources. It seeks to work on communication situations in the English language of these professions, such as conducting job interviews, presenting projects at conferences in the area, explaining the operation of an algorithm, or explaining problems and challenges in installing software or in information security. Its content is also to teach students how to improve their curriculum and *LinkedIn* in English.
Virtual learning environment	It is hosted on the *Udemy* platform: https://www.udemy.com/course/curso-de-ingles-para-ti/ It offers the possibility to join a group on *Telegram* as well.
Extra information	The course offers a certificate at the end. It can also be accessed on a mobile device. The course is aimed at students already at an intermediate level in English. There is also a continuation course on the same platform entitled "English Conversation Course for Information Technology"
CURSO DE INGLÊS TÉCNICO PARA INFORMÁTICA	
Created by	Cursos Avante
Slogan	There is not a slogan highlighted on the website.
Idea of the language learning process	It says to emphasizes the use of the language in a specific context, the IT area. However, it has a greater focus on reading and reading strategies, as well as technical vocabulary.
Investment	BRL 67,00
Course structure	The course is aimed at the following professions: PC operators, IT instructors, system analysts, programmers, students and university students, salespeople and representatives. On the homepage of the course, it is shown the following curriculum of contents: – Interpretation of technical texts in English.

	– Acquisition of technical vocabulary. – Technical pronunciations. – Grammatical and morphological aspects of the English language contextualized in the computing area. – Strategies for technical reading of the English language.
Virtual learning environment	It has its own platform: https://cursosavante.com.br/produto/curso-de-ingles-tecnico-para-informatica/
Extra information	It offers a certificate at the end of the course. By purchasing the Technical English for Computing Course, you have access to other courses on the platform, such as the English Proficiency Assessment Course or the English Course for School Context.

We can notice from this analysis that the few existing English courses for professionals in the technology area — 3 so far — are generally offered by platforms of professional courses, not necessarily designed by language teachers. We can also point out that these courses do not include the four language skills in their tasks, each of them is focusing on a specific skill whether speaking or writing. Usually, reading and reading strategies are the focus of these courses, and the technical vocabulary is the aspect that stands out the most among them, assuming a great role in its curriculum.

Discussion

As shown in the results, there is still a distance between the students' needs and the reality of informal online English courses aimed at Brazilian students in the technology area. In the needs analysis questionnaire, a student commented that most of the ESP or Instrumental English courses are focused on mainly reading strategies and basic vocabulary of the field but according to him, it does not help the students complete the numerous professional tasks in which they have to use the English language. Celani (2009) had been critiquing this superficial curriculum of ESP courses for more than a decade. However, the informal English courses that we analyzed in this research corroborate with this discussion showing that the ESP courses still see language learning as just technical vocabulary and reading and writing activities, besides they sometimes say otherwise in the advertisement.

ESP (Araki, 2013) and STEAM (Shatunova et al, 2019) approaches defend an interdisciplinary and integrative point of view of knowledge, and, for that reason, a course, especially for the technology field, should provide more meaningful learning. Having language and technology specialists in the course's design team is a first step along with a previously made substantial needs analysis. It is important to understand what the students' interests and difficulties are and what the area of technology asks from them, and then planning the curriculum. We should not forget again that a constant evaluation of the course and the field is necessary in order to stay updated and relevant to the students. The STEAM steps (Miralimovna,

2022) - observing, asking questions, making predictions, experimenting, and discussing - should be a cycle, not a linear path that has an end.

In ESP and general English study area, it has been discussed for a while that learning and teaching processes should follow a contextualized methodology, usually teaching through text genres and the four language skills. It challenges us to propose tasks that integrate more than one skill since in real life they are not separate (Shamsitdinova, 2018). This is not something we see in the courses analyzed in this paper. Although some of them mention genres or more than one skill on their website, this does not apply in their curriculum.

Final considerations

In general, the number of informal online additional language courses aimed at the Brazilian public has intensified in recent years, as has their demand, which is a valuable advantage for Brazilian education in general. In the Education 4.0 era, where technologies are part of our lives, informal and formal learning are linked and together can boost knowledge learning and even its production.

However, it is necessary to improve the quality of the online courses' designs as well as their diversity, above all the area of English for Specific Purposes. We must offer ESP courses with a solid theoretical foundation based on recent studies, like STEAM studies, following the interdisciplinary approach that the area needs. As teachers, we should participate in interdisciplinary groups to collaborate in the architecture of qualified online courses.

References

Araki, L. E. (2013). *A disciplina Inglês Instrumental no Ensino Superior e as representações de seus professores: um estudo de caso*. [Master thesis, Pontifícia Universidade Católica de São Paulo].

Araújo, C.F; Pinto, J. G. O.; Dias, K. C.; Mariano, A. M.; Monteiro, S. B. S.; Santos, M. R.; Baumann, B. (2019). Explicando a aceitação e uso do YouTube como plataforma de aprendizagem on-line: Um estudo por meio das equações estruturais. In *PAEE/ALE'2019, 11th International Symposium on Project Approaches in Engineering Education (PAEE) and 16th Active Learning in Engineering Education Workshop (ALE)*, 636-641.

Behar, P. (2009). Introdução: modelos pedagógicos em educação a distância. In Behar, P. (Org.) *Modelos pedagógicos em educação a distância*. Artmed.

Celani, M. A. A. (2009). Revivendo a aventura: Desafios, encontros e desencontros. In Celani, M. A. A.; Freire, M. M.; Ramos, R. de C. G. *A abordagem instrumental no Brasil: Um projeto, seus percursos e seus desdobramentos.* Mercado das Letras.

Finardi, K. R.; Preabianca, G. V.; Momm, C. F. (2013). Tecnologia na educação: o caso da internet e do inglês como linguagens de inclusão. *Cadernos do IL*, 46, 193–208. https://doi.org/10.22456/2236-6385.35931

Irshad, I.; Anwar, B. (2018). Designing English for Specific Purposes Course for Computer

Science Students. *Journal of Education and Educational Developement*, 5(1), 156-171.

Johns, A. M.; Salmani Nodoushan, M. A. (2015). English for Specific Purposes: The state of the art (An online interview with Ann M. Johns). *International Journal of Language Studies,* 9(2), 113-120.

Miralimovna, M. Y. (2022). Integrating Steam in English Language Classrooms (K1-K2). *International Journal on Integrated Education,* (5)2, 140-144.

Monteiro, A. C. S.; Bezerra, D. de S. (2012). A língua estrangeira (inglês) no curso técnico integrado em informática: o amálgama de opiniões de uma comunidade escolar. In: *Anais da 9ª Semana de Licenciatura.* 9ª Semana de Licenciatura: A prática docente e o desafio de ensinar na diversidade, Jataí/GO, 1-11.

Neves, C. das N. das. (2019). *Análise de necessidades em um curso técnico integrado ao Ensino Médio em Informática para Internet.* [Doctoral dissertation, Universidade Estadual Paulista Júlio de Mesquita Filho].

Oliveira, A. C. de; Cooper, J. S. (2018). Inglês para tecnologia da informação: um curso FIC em um campus do Instituto Federal do Rio Grande do Norte. *The ESPecialist:* Descrição, Ensino e Aprendizagem, 39 (1), 1-22. https://doi.org/10.23925/2318-7115.2018v39i1a6

Painel TIC COVID-19. (2020). Pesquisa sobre o uso da Internet no Brasil durante a pandemia do Novo Coronavírus. 3rd edition. Ensino remoto e teletrabalho. Cetic.br, Nic.br, Cgi.br. ttps://cetic.br/media/docs/publicacoes/2/20201104182616/painel_tic_covid19_3edicao_livro%20eletr%C3%B4nico.pdf

Perignat, E.; Katz-Buonincontro, J. (2019). STEAM in practice and research: An integrative literature review. *Thinking Skills and Creativity*, 31, 31-43. https://doi.org/10.1016/j.tsc.2018.10.002

Pincreobutr, V. (2016). Education 4.0: New Challenge of Learning. *St. Theresa Journal of Humanities and Social Sciences*, 2(2), 92-97.

Shamsitdinova, M. (2018) Methodological and linguistic bases for integrating the four skills. *Review of Law Sciences*. 2 (4), 117-119.

Shatunova, O.; Anisimova, T.; Sabirova, F.; Kalimullina, O. (2019). STEAM as an innovative educational technology. *Journal of Social Studies Education Research*, (10)2, 131-144.

Stake, R. E. (1999) Investigación con estudio de casos. Morata.

Viana, J.; Costa, F. A.; Peralta, H. (2017). Aprendizagens pessoais em contextos informais: oportunidades criadas pela Internet. *Revista Observatório*, 3(4), 190-231. doi: http://dx.doi.org/10.20873/uft.2447-4266.2017v3n4p190

Yin, R. K. (2014). *Estudo de caso:* planejamento e métodos. Bookman,

COMMUNITY-BASED SCIENCE EDUCATION RESEARCH

SCIENCE IN INFORMAL LEARNING SPACES: TINKERING SPACE AT SCIENCE WORLD

KRISTIN LEE
Exhibition Manager, Science World

Abstract

Creating tinkering spaces in informal learning places requires research, testing, prototyping, and evaluation. Designing the space and programming can be an iterative process and could take years to create something that works. Science World takes on the approach of creating and designing a tinkering space by using the design process and collaborating with partners. We evaluated the process and took observations to ensure the tinkering space met the criteria we set forth. The creation of the Tinkering Space was thoughtfully created and designed with the visitor's experience at the forefront.

Introduction

Aside from unique architecture, Science World has become iconic for families in Vancouver to explore hands-on exhibits and galleries that nurture their process of discovery and inspire connection with their natural, physical, and built environments. Our value of inquiry-rich, play-based, cross-disciplinary learning is embedded in every aspect of design, from fun interactive exhibits, engaging stage shows, and unique school programs. Throughout Science World you will discover that each gallery focuses on different themes and topics. Gallery spaces have their own narratives, learning goals, and outcomes. One of the newest galleries at Science World is our Tinkering Space: The WorkSafeBC Gallery.

Tinkering can be thought of as something similar to that of maker activities (Bevan, 2014). We can think of these activities to help build a maker mindset in visitors and to get them to do activities that support a different mindset.

The Tinkering Space has daily tinkering programming where you can solve problems, make new things from existing parts, create something cool and imaginative, and learn through experimenting and making mistakes. You'll also learn about the science behind safety and how important it is to choose the right tools for the job. This informal learning environment captures the playful spirit of Science World all in one place. Creating the Tinkering Space is an iterative journey, and we continue to work hard to build out the visitor experience and pedagogical practice we have today.

The Tinkering Experience

After many years working at Science World, I still experience the wonder and joy of seeing visitors and staff engaging with the interactive exhibits in the building. The eyes of delight and curiosity as families bring their children into the building for the first (or hundredth) time is incredibly rewarding. Designing captivating experiences is our goal and our mission, as we research the current and most relevant practices in the museum industry.

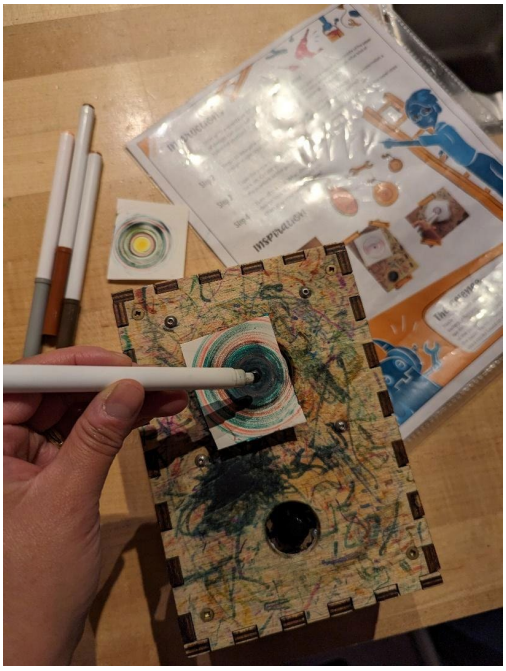
Whenever visitors enter the Tinkering Space, they get hit with its colourful and fun aesthetic, its welcoming space, and hands-on tinkering experiments. When you enter you are greeted by a science facilitator asking if you would like to participate in today's activity. As you look around the room, tools and equipment adorn the walls. You get a sense of wonder and excitement like you are meant to create and build something of your own in the space. The front half of the gallery contains wooden KEVA building blocks. The displays show a variety of different KEVA structures to prompt creativity and design. The backspace is intended for facilitated activities and school workshops. In between the two spaces are interactive exhibits that focus on workplace safety. The emphasis on safety is important in this gallery as it builds skills for future scientists, engineers, and artists.

I am captivated by seeing families engaging with the tinkering activities. Adults and science facilitators explain the activities to the kids and their young faces light up with the

thought of creating and learning something new, or even building on skills they already know. Carefully chosen open-ended challenges in the programming space allow visitors to "think with their hands" and prompt them to "think outside the box". Tinkering challenges are inherently cross-curricular, or Science, Technology, Engineering, Arts, and Mathematics (STEAM) activities. For example, folding and modifying origami models incorporates math, art and engineering, while building "wiggle bots" is an exercise in circuitry, sculpture and structural design. Wiggle bots are simple robots that can shake, wiggle, and dance.

Many of these activities and challenges use common and familiar materials and are designed to invite inquiry as well as artistic creativity. For example, the "spin art" activity adds a motor to felt-tip pens and paper to invite visitors to play with rotational physics and math.

Figure 1. *Spin Art activity in the Tinkering Space*



Note. This image shows the Spin Art Activity. We want to make sure that these tinkering explorations draw the interest of a variety of visitor demographics. Used with Permission. Photo credit: Kristin Lee

Tinkering activities are designed to have "low floor, high ceiling, wide walls"; in other words, they are easy to start, are rich in inquiry potential, and appeal to a broad demographic of learners.

To provide a design experience for the widest possible age spectrum, the front part of the Tinkering Gallery is filled with wooden KEVA planks.

The name "KEVA" stands for "Knowledge – Exploration – Visual Arts," reflecting the educational and creative aspects the building blocks encourage. Each planks measures ¼" thick,

¾" wide, and 4 ½" long. A box of KEVA plans offers builders an opportunity to explore mathematical relationships, structural stability and problem-solving. Armed with an instruction card, visitors can build their skills by copying the designs on the card, and then get creative and let their imaginations go wild. The versatility and open-ended nature of the blocks encourage visitors to return again and again to try new experiments.

Figure 2. *KEVA building blocks are simple wooden planks but can hold tremendous amounts of value. Playing with the blocks can facilitate visitor learning about design, engineering, and inventing.*

Note. KEVA Planks exhibit at Science World. Used with permission. Photo credit: Science World.

As visitors walk in today, they are drawn into our newest program called the Maker Studio, a brand-new program that allows our guests to create and design using industry tools such as 3D printers, Cricut smart cutting machines, and sewing machines. This is the most elaborate manifestation at Science World of "constructionism" – Seymour Papert's description of the learning that happens while making something that is meaningful to the maker (Stager, 2016). Maker Studio is a safe and facilitated space to be introduced to new skills and tools, while working through a design cycle. A high ratio of facilitators to participants means that Maker Studio experiences are individualized and responsive to visitors' different levels of expertise. Participants feel ownership throughout the design process as they design and make something for themselves.

The Design Process

The Tinkering Space did not always exist in the space that it is today. It was a dream to create a space where we could allow visitors to make and tinker with tools and materials. The gallery took many years to develop, and it is a continuous project to make sure we are practicing and using the most current tools, methodology, and museum practices.

Science World has always had "loose parts" exhibits and areas that allowed for some level of tinkering and creating. For example, Contraption Corner offered games, puzzles, table activities and inventor kits. Each inventor kit contained tools and materials that allowed a visitor to create and build an "invention" such as a ball launcher, a flashlight, or a motorized cart. However, the step-to-step instructions made the activity feel more like an assembly than an open-ended tinkering task.

Over the many years, Contraption Corner ceased to exist. As the years went by, we wanted to create a dedicated space with tools and materials and fill it with open-ended activities that could be used for facilitation. Science World decided to create a tinkering space, inspired by the Tinkering Studio at the Exploratorium in San Francisco and Fabrik at the Montreal Science Centre.

When we first came up with the concept of the Tinkering Space, we really wanted to expose our visitors to the idea of design thinking and using the iterative design process (Question-Imagine-Create-Test and Repeat). This process is the foundation to our exhibits, facilitation, and programming. Thus, the Tinkering Space has become a living and evolving hub for tinkering and implementing the creative process. The design process is similar to NASA's Engineering Design Process that helps engineers solve problems (STEMOnstrations, n.d.-b).

We also recognise that the context of the learning matters, designing visitor experiences around collaborative learning models and using physical design principles drawn from the Reggio Emilia philosophy, where the learning environment is seen as the 'third teacher'. The walls of the Tinkering Space are decorated with tools and with sample KEVA structures, and the tables are designed for groups to gather around with some materials displayed in the centre – and other materials in a common area to encourage cross-group collaboration. The design cycle is made concrete by a rotating overhead sign that reads "Question Imagine Create Test".

Tinkering is an engaging way to provide our visitors with creative thinking skills. It offers a fun means to learn by doing and to think with your hands. We wanted to make sure that we were capturing these skills to allow visitors to repair, adjust, and improve their creations without barriers.

We hope that when visitors explore the space, they can take home these key messages:

- I am creative.
- I need to know how to use tools properly and safely before I use them.

- Thinking about safety is part of my everyday life.
- I like to create with my hands.

Throughout the gallery development, we learn and observe from our visitors. They teach us how to develop and design innovative exhibits with clear learning objectives. Observing visitors' learning in the space and while they are programming allows us to practice and evolve our science communication. It allows us to make sure we keep current and use emergent learning practices. These practices come from teachers, educators, museum industry, and classrooms. To keep up with all these practices we must make sure to be flexible and agile. We want to make changes quickly to ensure the visitors are getting the best experience.

Working with Community Partners

During our design processes we collaborate with community partners, content experts, and Science World members. Through collaboration, we can ensure that we present the most accurate, up-to-date, and relevant information.

In creating the Tinkering Space, we worked with WorkSafe BC as content experts on workplace safety. Working with partners like WorkSafeBC taught us about communicating effectively and efficiently with partners. It is important to identify the key learning messages, and outcomes together. Once we have our key messages, we can use this information to determine how we will implement them into the balance of experience across the exhibition. These messages are brought to our Exhibits Design team to create exhibits and experiences that can capture and communicate the learning outcomes.

As well as their expertise, community partners also bring in different perspectives to the museum setting. Often, as museum educators we forget that we are not content experts in every field and sometimes the message incorrectly gets translated to the visitors. There is often specific vocabulary that is used in different subject matter or certain topics that may have more current and accurate information. To make sure that we are getting this information correct we ask our partners to review and vet our content.

We often work with local community partners to help educate and inform our visitors about different initiatives and messaging. Along with presenting useful resources within our exhibits and galleries, Science World can help provide an avenue to pass on important messaging to our visitors. Our collaboration with WorkSafe BC in the Tinkering Space made sure to highlight the importance of safety in the workplace and to get visitors to critically analyse their perspectives on safety.

When working with community partners we make sure that both parties' benefit and learn from each other. Partnering only makes sense if we share common goals or missions. We want to make sure we choose what we design and present as well as making sure that our partners are the right ones to work with. Mutual collaboration is ideal for a good working relationship.

Inquiry-rich Programming

The Tinkering Space is about "thinking with your hands". Visitors can make mistakes and experiment in a welcoming, safe environment, and are encouraged to take part in the iterative design cycle. They generate their own questions and are provided with the tools and materials to answer those questions.

Safety is crucial to good tinkering. Providing visitors with the opportunity to learn how to use new tools properly and safely allows them to expand their creative boundaries. In the Tinkering Space, we scaffold visitor's learning based on their prior experience, so they can feel comfortable taking risks by trying new skills or by putting materials together in new ways.

Facilitators encourage visitors to work collaboratively with one another. This builds skills essential for teamwork, communication, and critical thinking.

Facilitators are trained not to jump in and "fix" visitor projects, but to ask questions and offer just-in-time tips. We don't offer step-by-step assembly instructions, but general guidelines and inquiry questions.

Conclusion

Keeping up to date with current and emerging informal learning practices involves connecting with other museums, industry educators, science facilitators, educators, and community partners. We attend webinars, conferences, and workshops to get the important information, trends, and technology. We find experts to help us identify holes, provide us with correct information or even point us in the right direction. We are active participants in our hope to inspire lifelong learning in our visitors.

References

Bevan, B., Gutwill, J. P., Petrich, M., & Wilkinson, K. (2014). Learning through stem-rich tinkering: Findings from a jointly negotiated research project taken up in practice. *Science Education*, *99*(1), 98–120. https://doi.org/10.1002/sce.21151

STEMOnstrations: Engineering Design Process. (n.d.-b). NASA. https://www.nasa.gov/stem-content/stemonstrations-engineering-design-process/

Stager, G. Seymour Papert (1928–2016). Nature 537, 308 (2016). https://doi.org/10.1038/537308a

FOSTERING A LIFELONG LOVE OF PLANTS: EDUCATOR STORIES FROM A BOTANICAL GARDEN

CHANTAL MARTIN
AYMARA PINEDA BARAHONA
DENNIS CHEN
JESSICA HENRY
MARINA PRINCZ
NATHAN FONG
SANGEETA THOMAS
TERRISA YUAN
NATASHA FRIEDMANN
Vancouver Botanical Gardens Association

MADELENA KLEIN
University of British Columbia

Abstract

With a growing interest in community-based STEAM education, 10 environmental educators with the Vancouver Botanical Gardens Association share their experiences connecting people to plants at VanDusen Botanical Garden and Bloedel Conservatory, located on the unceded ancestral shared lands of the xʷməθkwəy̓əm (Musqueam), Skwxwú7mesh (Squamish), and Sə́lílwətaʔ/Selilwitulh (Tsleil-Waututh) Nations. Each educator contributes various perspectives based on their unique backgrounds and lived experiences that culminate in a shared story of passion for the natural world and its belonging in STEAM education. This narrative demonstrates that STEAM education flourishes when informal and formal educators work collaboratively and embrace new educational opportunities, engage senses through experiential place-based education, explore Two-Eyed Seeing and reciprocity, include diverse perspectives and recognize how lived experiences shape worldview, share passion and curiosity with learners, and foster appreciation of the natural world.

Fostering a Lifelong Love of Plants: Educator Stories from a Botanical Garden

Introduction

On any given day, rain, or shine, you will find a team of passionate informal educators connecting people to plants at VanDusen Botanical Garden or Bloedel Conservatory. Brought together by their love of nature and experiential education, this group of educators consists of full-time, part-time, and casual employees, research fellows, co-op and career placement students, and volunteers. Located on the unceded ancestral shared lands of the xʷməθkwəy̓əm (Musqueam), Skwxwú7mesh (Squamish), and Səl̓ilwətaʔ/Selilwitulh (Tsleil-Waututh) Nations, the Vancouver Botanical Gardens Association (VBGA) is honoured to- operate on these lands, where these Nations have lived since time immemorial, and where they continue to maintain reciprocal relations in nature. In 2022, the team shared their passion for a sustainable future through plant education on these lands with over 14,000 participants.

This group of unique educators work or volunteer with the Vancouver Botanical Gardens Association (VBGA). The VBGA is a charitable non-profit whose mission is to engage people of all ages and walks of life in the importance of biodiversity to our lives, and to foster among them a lifelong love of plants and gardens by virtue of their participation in our programs and services. The VBGA jointly operates both the Garden and the Conservatory with the Vancouver Board of Parks and Recreation to achieve a joint strategic mission to inspire a deeper understanding of plants, a passion for biodiversity, and to encourage generations to conserve, protect, and enhance the natural world. The Canadian Museums Association (n.d.) considers botanical gardens as museums, and like other museums, our Gardens include plants for public display, education, conservation, and research purposes (Jackson, 1999).

To guide the delivery of diverse mission-aligned programs for learners of all ages, VBGA educators look to nature as our teacher, and community as our council. For the VBGA, community includes VBGA members, education participants, teachers and students, Indigenous partners, and stakeholders in environmental sustainability. Collaboration strengthens our ability to provide deeper engagement in nature by incorporating unique lived experiences, knowledge, and experience in STEAM education. Engaging learners in experiential plant programming complements and strengthens learning in formal learning spaces (Bauerle & Park, 2012). By fostering a student's sense of belonging within nature, formal and non-formal educators can work together to encourage pro-environmental behaviour (Lumber et al., 2017).

Mirroring the carefully curated collections of plants growing in our Gardens, this is a collection of curated environmental education experiences facilitated in our 55-acre living classroom and under our lush tropical dome, as told from the perspectives of educators. The intention is to inspire community relationship-building outside of the formal classroom, which not only encourages a love of STEAM, but also empowers students to share their gifts with the world.

Aymara Pineda Barahona - Adult Education Coordinator

"Learning doesn't end after childhood; we can continue to engage our senses in nature for life."

As a child, it seemed implausible to me that my mother loved the smell of cow manure but hated perfumes. Despite being born and raised in an agricultural country, Nicaragua, I only developed a deep appreciation for nature as a young adult.

My connection began emotionally, and only after creating that bond and finding solace and peace in the Mombacho Volcano Natural Reserve during a challenging period, only then, it grew stronger as this experience motivated me to learn more about ecology, health, and our dependence on nature through courses, reading, and volunteering (Figure 1).

Figure 1. *A Day at Mombacho Volcano Natural Reserve*

Note. Personal photo collage provided by Aymara Pineda Barahona.

Now, as the Adult Nature Education Coordinator at VanDusen, I am thrilled to help promote and strengthen this connection in other adults, not only rationally, disseminating specialized knowledge on botany and gardening by professionals with academic and in-field experience, but also emotionally, upholding the idea that we, adults, need to experience the natural world with all our senses as it is the only way of saving and preserving the ecosystems we know today and on which our lives depend.

With the kind collaboration of eleven volunteer education hosts and the education team, our yearly calendar offers around 60 short programs that provide fundamental knowledge, tools, and skills for adults to deepen their understanding and connection with nature. Furthermore, the courses also serve as an opportunity for participants to build a like-minded community, supporting each other in their journey.

For instance, the "Growing Chinese Medicinal Plants in Your Garden" course led to the creation of a small community among participants interested in sharing their adventures on this subject since they think there is a limited direct experience in this field in the city. They started by organizing a picnic after the last session, a guided walk to identify and discuss the properties of Chinese medicinal plants growing in the Garden.

Similarly, the watercolour courses foster friendships among attendees who often return to meet their partners in art repeatedly. Everyone takes out their painting materials and sets up their worktable, participants choose the plant samples they like best from a variety of specimens we cut for them in the Garden to guide their drawing and painting, and there is calm energy in the air, including small conversations in the background. There is undoubtedly a flow in the classroom during art courses!

Our non-traditional educational programs also include, among others, Chigiri-Paper Art, storytelling and hula dancing at Bloedel Conservatory, guided walks through VanDusen with a focus on specific insects or plants, and the Multisensory Nature Immersion program, which is the new title given to the Forest Bathing or Forest Therapy program. The latter highlights the connection between outdoor learning, science, wellness, and heightened senses. This practice originated in Japan and studies on Forest Therapy have demonstrated a wide array of health benefits, especially in the cardiovascular and immune systems, and for stabilizing and improving mood and cognition (Hansen et al., 2017). There is a strong body of scientific evidence documenting health benefits, as outlined in the Shinrin-Yoku (Forest Bathing) and Nature Therapy: A State-of-the-Art Review by Hansen, M. M., Jones, R., & Tocchini, K. published in The International Journal of Environmental Research and Public Health (2017). Forest Therapy can support emotional, physical, psychological, and spiritual wellness while reducing stress and potential burnout (Hansen et al., 2017).

Participants often express their joy and gratitude for the valuable lessons they learn during this outdoor program, such as "being one with nature," "slowing down and tuning into the

senses," and "the importance of stepping away from the city to de-stress and appreciate nature's offerings."

Chantal Martin - Director of Education and Research

"STEAM education flourishes when we include diverse perspectives."

In my early adulthood, I learned from a neighbour that kale did not always look like the kale I eat in my salad, as it changes throughout its life cycle. I recall excitedly sharing my newfound knowledge with a friend. "Did you know this spindly plant with bean-like seed pods is kale?" I asked. My friend replied: "Here we go again, you're such a know-it-all!". Although my reaction in the moment was shame and embarrassment, I now encourage folks to share their nature discoveries with the world. I recognize that what was happening during my early adulthood was a growing curiosity for the plants around me, sparked by my community. In this case, my neighbour was growing kale amongst other food within their limited shared concrete parking space. She had learned this technique from her mother and generations past. Her knowledge of food-growing techniques was facilitated through hands-on engagement.

Since this time my curiosity bloomed from not only learning about the common food found on my plate, but also the traditional plant foods growing on these lands. I have had the honour and privilege to teach on the shared unceded traditional and ancestral lands of the xʷməθkwəy̓əm (Musqueam), Skwxwú7mesh (Squamish), and Səl̓ílwətaʔ/Selilwitulh (Tsleil-Waututh) Nations, in the city commonly known as Vancouver, British Columbia for over 20 years. Xʷməθkwəy̓əm, Skwxwú7mesh, and Səl̓ílwətaʔ/Selilwitulh peoples are stewards of these lands and have deep knowledge and connection to the plants and the land that have sustained their people for time immemorial. As environmental educators, we are part of the growing group of formal and non-formal educators that understand Indigenous perspectives and knowledge are crucial to learning on the land that we live on. We work to honour the host Nations' knowledge and protocols and continue to build relations in a good way. Understanding it is not our story to tell, we work with Indigenous partners to facilitate culturally appropriate and relevant education for youth and adults. We also purchase resources created by Indigenous Peoples such as Indigenous literature available for educators to borrow from our library and plant flashcards created by Indigenous knowledge keepers in our field trip programs. The education team prioritizes centering Indigenous perspectives and the teachings of reciprocity. Our community includes Indigenous Peoples, and we work to amplify their voices.

In delivering STEAM education, we approach with the lens of Two-Eyed Seeing as coined by Albert Marshal, a Mi'kmaq elder. *"Two-Eyed Seeing refers to learning to see from one eye with the strengths of Indigenous ways of knowing and from the other eye with the strengths of Western ways of knowing and to using both of these eyes together"* (Bartlett et al., 2012). Therefore, our educational programs also rely on the academic community.

For the past 4 years, we have awarded fellowships to students through the Institute for Environmental Learning. The fellows bring unique educational backgrounds but are also encouraged to share their lived experiences. Dr. Poh Tan has been a VBGA Fellow for the past two years, where she has been creating a virtual field trip titled "Classroom Visit to the Bloedel Conservatory." Focused on STEAM education, the resource brings tropical plants to the traditional classroom setting. Dr. Tan highlights the unique relationships between people and plants, from the perspective of the people where the plants are endemic and naturalized. As a result of working with Dr. Tan, I have come to gain an appreciation for the bananas I pack in my children's lunches regularly. Through Dr. Tan's Malaysian-based storytelling included in the field trip, I learned of a ghost called Pontianak that lives in the banana tree. She explains that cultural stories such as these can be a preventative safety measure to keep children safe from the animals that live or interact with the banana tree. Learning about ecology is a by-product of this immersive cultural storytelling experience. Dr. Tan involved her community, by bringing her hula sisters, family, and other fellows together to make the virtual field trip a truly unique opportunity for elementary students and their teachers (Figure 2).

Figure 2. *Community Collaboration at Bloedel Conservatory*

Note. Personal photo provided by Dr. Poh Tan.

From learning the life cycle of kale, practicing reciprocity with plants, to gaining a better understanding of the cultural significance of bananas to global communities, I continue to not only be inspired by the biodiversity around me, but also by the natural and cultural knowledge of plants shared by the people who know them in their place.

Dennis Chen - Youth Programs Manager

"Field trips to botanical gardens have endless potential, such as enhancing classroom learning."

Take the tip of a pipe cleaner and fold it over. The little bulb at the end is the average size of a mason bee. Fold it over again, and you have a shape representing a honeybee. Fold it once more and you will have the semblance of a bumblebee. Swipe the pipe cleaner against the stamens in a flower and observe the pollen collected by the bristles before depositing it in the next blossom (Figure 3). This exercise, which teaches students first-hand about the role that bees play in pollination, is just one example of the many activities featured in our field trip programs.

Figure 3. *Holding a Pipe Cleaner "Bee"*

Note. Photo provided by the Vancouver Botanical Gardens Association.

Highly accomplished educator, Alyx Kellington, explained that "field trips enrich and expand the curriculum, strengthen observation skills by immersing children into sensory activities, increase children's knowledge in a particular subject area and expand children's awareness of their own community" (Kellington, 2011, para. 5). This is exactly what we strive to do at the VBGA. As the Youth Programs Manager, one of my main responsibilities is to ensure that visiting students receive a learning experience that enhances their classroom education, often through tactile activities such as the one described in the previous paragraph.

It is this ability to enhance education that makes out-of-classroom learning important. For this reason, as Kellington continues, "often teachers look to the arts and cultural organizations of their community for field trip ideas: museums, zoos, science centers, and natural areas" (Kellington, 2011, para. 9). To help share the work that we do, the VBGA participates in the University of British Columbia's Community Field Experience Program where, over the course of three weeks, elementary and secondary teacher candidates can observe, develop, and deliver the opportunities we provide students.

The most rewarding part of the work that we do is to see both teachers and students excited about the content they experienced. Hearing a group of children talking about the fuzzy bodies of bees or a teacher sharing that the "kids were very engaged [and the] activity was clear and age-appropriate," are all signs that the education we provide is effective (Anonymous, personal communication, 2022). Field trips are important and vital for learning.

Jessica Henry - Adult and Family Programs Manager

"The best part about teaching a teacher is that you know the information or ideas you are sharing will travel outwards into the community and have a wide ripple of impact."

Teacher Professional Development at VanDusen Botanical Garden is designed to create programs inviting teachers to consider the critical importance of plants to our world and ourselves. Plants are easily overlooked by teachers and curriculums alike, and many teachers I work with tell me that they possess little to no botanical knowledge, or even contact with plants beyond the grocery store produce aisle. Plants are everywhere, they are accessible (although, not with equal access), and they offer approachable ways to engage directly with the non-human biodiversity of species outside the classroom door.

With many more teachers in Canada beginning to embrace the concept of taking their students outside, with an extra boost to buy-in due to the pandemic, and mounting research showing the benefits to all of us for time spent in nature settings (Capaldi et al., 2015), our outdoor-based professional development programs are driven by a desire to invite teachers to step into the Botanical Garden and create a connection to the wide world of plants.

As a long-time, non-formal educator with decades of experience in wilderness, agricultural, and urban-wild spaces, my primary goal, outside of the formal content and skill-based learning objectives for all teacher education programs, is to create immersive personal experiences that generate wonder and curiosity in teacher participants, first and foremost.

The experience of engaging with the natural world, let alone the concept of taking your students outside to learn, can be daunting for many teachers who may not come from a personal or cultural background where spending time outside, with dirt and mud, insects, and weather is the norm. How can we task teachers with asking their students to make meaningful, personal connections to the wilder world if they themselves are not making these connections or having these experiences? A Botanical Garden, or similarly familiar and curated outdoor space, can be a welcoming environment to ask people from any background to step off the paved path for a moment and engage (Figure 4). A Garden can be a surprisingly wild space, albeit a gentle and domesticated sort of wild, and in this accessible environment, we can facilitate a host of novel nature experiences.

Figure 4. *A Moment of Connection to the Learning, Inside the Douglas Fir Grove at VanDusen Botanical Garden*

Note. Photo taken by Tina Chin for the Vancouver Botanical Gardens Association.

Teachers tell us they come to workshops at the Garden to gain new knowledge, take home new activities with which to engage their students back in the classroom, and enjoy the beauty of the space, but the biggest seems to be in the opportunity to step off the path and stand under the canopy of a Giant Sequoia, with an invitation to look up and wonder about the life of this non-human organism, and how that life is connected to theirs.

Layered with relevant knowledge and skill transfer, practical modeling of outdoor-education best practices, and applicable classroom activities and resources, our goal is to craft opportunities to connect these personal nature experiences to curriculum and spark a curiosity teachers can take back to their classrooms to ignite similar moments of connection with their students.

Madelena Klein – UBC LFS Summer Career Practicum Student

"Through experiential education programs at VBGA, the presence of STEAM/STEM subject matter provides an individualistic, transferrable and resonant connection to plants and nature for students and campers alike."

Throughout my summer practicum placement with VBGA, I have experienced firsthand the multifunctional nature-based education, specifically in the scope of youth programming. My placement began in mid-May; so my position has seen the last portion of the school year and the

majority of summer camp facilitations. Specifically, my role as a camp assistant focuses on both administrative and facilitative matters of camp. I have had the privilege of leading campers through workshop installments of interactive activities and games (Figure 5). Through experiential education programs at VBGA, the presence of STEAM/STEM subject matter provides an individualistic, transferrable, and resonant connection to plants and nature for students and campers alike.

Figure 5. *Children Investigating Stumps for Decomposers During a Workshop Installment*

Note. Photo taken by Tina Chin for the Vancouver Botanical Gardens Association.

Coming from a nutrition degree background, themes of food literacy are familiar to me and have been explored throughout my courses. In an environment such as the Garden, this presents itself in an even more integrated manner. Food literacy can be taken from the classroom with direct and tangible experiences to foster an evolving connection to food and the strong foundation of an evolving food literacy.

Throughout my experience, it has been clear that fostering connections to nature that radiate beyond the borders of the Garden is the value of VBGA's programs. A self-driven, hands-on discovery through nature-based education has impressionable impacts on the student or camper that has the power to develop into an evolving and continuous connection, appreciation, and curiosity of nature. I have realized the activities that seem to be the most effective and

engaging are those that highlight agency, collaboration, and individualistic curiosity. These same principles present themselves in a nature-situated learning environment. This application and experiential moment for a student or camper is one they can own, apply, and recognize in a variety of environments, ultimately cultivating a developing relationship with nature.

Marina Princz - Library Coordinator

"One's passion can leave an indelible mark on a student, and spark something one could never foresee."

It has been such a pleasure to see little ones first gain that excitement for learning and understanding the natural world in which they live!

As the Library Coordinator, I have been organizing Preschool Storytime at the Yosef Wosk Library & Resource Centre at VanDusen Botanical Garden for the last 6 years. The volunteer teachers I have worked with have been extremely passionate about passing their knowledge and enthusiasm onto the 3 to 5-year-olds (and their families) who attend the program (Figure 6).

Figure 6. *Preschool Storytime at the Yosef Wosk Library & Resource Centre*

Note. Photo taken by Tina Chin for the Vancouver Botanical Gardens Association.

Many of the children, especially those with older siblings, proudly speak about our library's Storytime program as their 'school', and our volunteer staff as their 'teachers.' Here, once a month, they join us for stories, songs, and a simple science or art-based project. We typically run a 2-year cycle with families since once the little ones reach 5, they move on to kindergarten or home-schooling.

Recently, Marilyn and Beverly, our Preschool Storytime volunteers spent a couple of hours in the library to plan for the upcoming fall programming. As life sometimes sweetly and unexpectedly provides, Leo- one of their 'graduates' who had regularly come accompanied by his grandmother, walked through the door. He had been a very bright little boy who always sat cross-legged at the front of the carpet, asked (and answered) many questions, and regularly reported back on the progress of the seeds they had started in the science project part of the program. Leo is now finishing grade 4, and we had not seen him for almost 5 years. Despite having grown tall and mature, he remains talkative and enthusiastic, is still passionate about science and nature, and has taken part in several nature-based enrichment programs over the past few years. In our 15-minute conversation, he specifically expressed his fond memories of Preschool Storytime and his love for VanDusen Botanical Gardens.

As Leo and his grandmother left, Marilyn wiped tears from her eyes. She said that she was feeling overwhelmed with joy because reconnecting with this older version of Leo made her realize the long-term impact of the work, she had so whole-heartedly put herself into since retirement. This unexpected meeting with a previous 'student' not only demonstrates the positive impacts of teaching young children about nature and natural cycles, but also that putting her heart, soul, and enthusiasm into her teaching ignited a similar passion in the little ones. This made her both happy for Leo and gave her hope for the future.

Natasha Friedmann - Assistant Manager of Youth Programs

"Exclaiming, "Go play outside" isn't a punishment, it's a privilege."

I will never forget the feeling of my hands sinking into the mud with a youthful fervor – as a child, I reveled in every moment I spent outside, and when my family moved from an upstairs townhouse to a freestanding house with a backyard, I was convinced it was all a dream. Hardly grown enough to see over the kitchen counter, I had not yet realized the privilege we held in this opportunity, nor did I fully appreciate the implication of having my own "mud kitchen" before they were known colloquially as such. Decades later, the importance of this type of exposure is the foundation of our programs and the driving force in our organization's mission and vision.

A large portion of the families that we serve fall under one of two categories: 1) Children that have extremely limited access to nature at home or at school in an urban environment like Vancouver (who we fondly refer to as "condo kids"), and were raised during the height of the

COVID-19 pandemic, further fracturing them from social and emotional connections made outdoors and in environments like schools, recreation programs, camps, etc. Or 2) Families from diverse backgrounds, often experiencing socio-economic hardship or other barriers to participation, such as recent immigrants, single caregivers, or those with disabilities. In any case, we believe that our programs, such as nature-based day camps (Figure 7), provide integral experiences and opportunities for fostering environmental literacy and age-appropriate outdoor play, as well as introducing concepts and careers in STEAM/STEM beyond a rigid concrete classroom. Whatever the reason, these young folks are susceptible to a disconnection from nature so detrimental to development it was once coined 'nature deficit disorder' (Louv, 2005).

Figure 7. *Leading Children on a Scavenger Hunt During a Camp*

Note. Photo taken by Tina Chin for the Vancouver Botanical Gardens Association.

Here, campers conduct experiments, hone navigation, design, and problem-solving skills, explore current events and young leaders and change-makers, use tools and technologies, and learn about life cycles and human interactions with the local ecology and First Peoples' Traditional Ecological Knowledge. The weight of this exposure is ultimately amplified by the stark reminder that this may be the participants' first exposure to an outdoor learning environment, or their first time applying or interacting with STEAM/STEM in a setting where none of the outcomes are graded.

Nathan Fong – Environmental Educator & Camp Leader

"Connecting children to place allows us to provide deeper and more meaningful learning opportunities than they might experience in a traditional classroom."

As someone who has lived his whole life in Vancouver, VanDusen Garden has always been a magical place. Towering trees, beautiful blooms, and a plethora of unique and rare species from across the globe find their home in one 55-acre plot of land in the middle of a bustling city. However, the most impressive aspect of VanDusen Garden is its ability to spark wonder and exploration by connecting people to place. In my role as a Camp Leader and Environmental Educator at VanDusen, I have had the privilege of witnessing countless instances of learning when children make connections to something in the garden (Figure 8).

Figure 8. *Children Examining a Story Pole in the BC Habitat Garden*

Note. Photo taken by Tina Chin for the Vancouver Botanical Gardens Association.

Spaces like VanDusen Garden offer a unique opportunity for children to learn differently than they might be able to in a traditional classroom setting. Classroom lessons and even experiments can sometimes be presented as carefully scripted talking points that may help children learn specific information but often fail to provide them the opportunity to enter into more complex learning (Clifford & Marinucci, 2008). While youth programming at VanDusen is typically themed and planned, I have come to see these plans more as guidelines that allow deeper learning to occur naturally. The ever-changing and energetic nature of summer camp also contributes to our ability to drop a pre-planned activity and take a deep dive into questions such

as, “Why are there mushrooms growing under that bench?” or, “Why do some of those ants have wings but others don’t?” I’ve witnessed children make connections to these embodied and real learning experiences that happen in the garden that allow them to draw greater conclusions to questions they have had about the world around them.

A pertinent example of one such connection comes from a few summers ago while I was leading a group of campers on a bird walk through the garden. Our organism of the day for that day was the black-capped chickadee so we provided campers with some basic information about the bird during our morning meeting. While on the bird walk, I asked the group to recount some of the information we learned about chickadees and questioned how that might help us spot them. Many of the campers responded by highlighting the chickadee’s unique mnemonic call where it seemingly repeats its own name. At that moment, we passed through a spot in the garden where chickadees were making that exact sound and the campers furiously focused their binoculars to try to get a glimpse of the action. From that point on, the walk became much more engaging as every new bird call ushered forth a chorus of voices exclaiming, “What was that bird?” or, “that one sounded different,” and, “I think I’ve heard that one before.”

A year later, while I was leading a different camp, one camper from that previous group ran up to me to share what her experience on that day taught her. Not only was she able to teach her new camp group about chickadees and identify them a year later, but she also learned that chickadees do not just live in Vancouver because she identified them while on vacation in another city. By forming a connection to her experience at VanDusen, this camper was able to learn new information beyond what we included in our plan for that one simple activity. Powerful learning opportunities such as this small example are plentiful in a space like VanDusen, where connecting to place allows us to push past the boundaries of a traditional classroom and engage children to learn about science in a deeper and more meaningful way.

Sangeeta Thomas- Teaching Garden Coordinator

“Plants may be silent, but they have remarkable, fantastic lives. Informal education can be very effective in telling their stories.”

Walking upon an outdoor space, e.g., an urban park, what is the first thing you notice? Most people may respond with “swing set,” or “a crow on a picnic table.” It would be a rarity if someone pointed out a tree, and rarer still, choose to mention a plant by name. “Plant Awareness Disparity” is a phenomenon where people fail to notice the existence and significance of plants in their daily lives (Brownlee et al., 2021).

I was like this for 22 years until one summer. Tired of being in lecture halls, I signed up for a plant course that took place outdoors. The professor took us on walks, where he would stop every few meters to share stories: stories of botanical discoveries, ethnobotanical uses, plant adaptations, and plant explorer adventures. We collected specimens to create an herbarium and

sketched our observations. I was nothing short of amazed by the knowledge contained within a small area! Being someone who previously had no affinity for the outdoors, thereafter I strove to do what that professor did for me: connect people to plants.

Having now led a variety of educational programming, such as preschool nature programs, adult-guided tours, and intergenerational hands-on workshops, I believe everyone, regardless of age, is wired to adore plants if provided with an initial spark. (Figure 9).

Figure 9. *Reading Provides an Opportunity to Calm Down, Collect Thoughts and Have Discussions Amidst a High-Energy Outdoor Pre-School Program*

Note. Photo taken by Tina Chin for the Vancouver Botanical Gardens Association.

Integrating diverse snippets of information about history, cultural uses, arts, and storytelling breathes life into the environmental sciences in a positive, engaging environment that makes participants feel delighted in our natural world. Many participants come back for more workshops, slowly fostering responsibility for conservation. Having mixed-age programming is effective in helping people across generations find common ground and connect to nature in ways only people of each age can make apparent. Having children around can help adults see things with eyes of playfulness and imagination, while adults can support children as their passions grow. Informal educational settings like the botanical garden help balance out the overall helplessness people feel when trying to learn about current environmental problems. Plants contain many sensational life stories; my job as an informal educator is merely to tell them.

Terrisa Yuan- Senior Environmental Educator

"*Through immersive field trips, we bridge gaps in access to nature, fostering exploration and cultivating a profound connection with the natural world for every child.*"

As a child growing up in the suburbs, I was blessed with the incredible privilege of having direct access to a spacious urban green space right in my backyard. Beyond the joy of playing, the green space offered valuable opportunities for experiences that instilled a sense of wonder and appreciation for nature in me. As I grew older and understood more about the concept of urban green equity, I realized that not all children have the same privilege as I did during my childhood. This realization ignited a passion in me to commit to creating opportunities for children to experience the wonders of nature, no matter where they live.

As the Senior Environmental Educator, I bring this commitment alive by facilitating field trips for elementary and secondary school students at the Garden, giving them a chance to explore, play, and connect with the natural world on field trips such as Pollinator Days (Figure 10).

Figure 10. *A Student Practicing Their Observation Skills in the Garden*

Note. Photo taken by Tina Chin for the Vancouver Botanical Gardens Association.

Pollinator Days is a 3 day-long field trip adventure for young nature enthusiasts, aiming to inspire their curiosity about pollinators and the environments that support them through STEM/STEAM activity stations that can be explored at their own pace. Teachers from all around Metro Vancouver bring their classes to VanDusen to explore the special relationships between plants, pollinators, and people. Our facilitators and community partners promote curiosity and stewardship through fun, diverse, hands-on activities at stations throughout the Garden that encourage new discoveries while aligning with the British Columbia curriculum. Our field trip festival's success is fueled by the active participation of numerous community partners who share a common interest in conservation and science education. They offer an array of rich and diverse perspectives that empower students to develop their own opinions and discover the STEM/STEAM areas that resonate most with them as learners.

Quinton et al. (2022) suggests that the relationship between proximity to urban vegetation and several factors such as household income and education is quite strong for Canadians living in cities. The VBGA strives to improve green equity through bursaries that are available for underserved schools and communities. It is through these bursaries that we, as non-formal educators, can foster a lifelong connection to the environment for future stewards of our planet. This is achieved through the transformative power of urban greenspaces in collaboration with STEM/STEAM learning opportunities outdoors.

Conclusion

At the Gardens, we plant the seeds of curiosity for our community, as someone or Mother Nature herself once did for us. For example, when a neighbour displayed kale's life cycle through gardening, or when Mombacho Volcano Natural Reserve sparked an interest in ecology, health, and dependence on nature, our educators were inspired to share and explore this newfound knowledge. These teachable moments can happen anywhere spontaneously; VanDusen Botanical Garden and Bloedel Conservatory provide endless natural opportunities to spark learning. When knowledge is passed on to our educators or when our educators pass on their learning experiences in the gardens or online, a community of passionate nature lovers continues to grow. For example, when a teacher visits us for professional development, they might stand under a Giant Seqoia looking up with amazement, and encourage their students to do the same, under any tree in their school yard or neighbourhood. Or when a career placement student develops and facilitates STEAM activities that incorporate their academic studies in nutrition, combined with their new learning at the Garden of traditional Indigenous foods, they return to their school and share Two-Eyed Seeing perspectives with their classmates. Through this collection of experiences shared by the VBGA’s educators, a story of opportunities emerges.

The VBGA story demonstrates that STEAM education flourishes when we (informal and formal educators):

- Engage our senses through experiential place-based education.
- Commit to being lifelong learners and open our hearts and minds to Two-Eyed Seeing.
- Include diverse perspectives and practice reciprocity with all people and the land itself.
- Work collaboratively inside and outside of the formal classroom.
- Spark curiosity for the learner by demonstrating our passion and curiosity.
- Embrace new opportunities for collaboration, often without a prescribed outcome.
- Recognize lived experiences and privileges shape how we experience the world, including STEAM education.
- Foster an appreciation of the natural world, with plants and humans included.

STEAM education facilitated through botanical gardens can spark a love of plants as demonstrated by the experiences of the VBGA's informal educators. Furthermore, these shared experiences reveal that STEAM education is engaging when community is involved, and approaches are diverse, creative, and collaborative.

References

Anonymous. (2022, May 16). Field Trip Evaluation Form. *Vancouver Botanical Gardens Association*.

Bartlett, C., Marshall, M., & Marshall, A. (2012). Two-Eyed seeing and other lessons learned within a co-learning journey of bringing together indigenous and mainstream knowledges and ways of knowing. *Journal of Environmental Studies and Sciences, 2*, 331–340. https://doi.org/10.1007/s13412-012-0086-8

Bauerle, T. L., & Park, T. D. (2012). Experiential learning enhances student knowledge retention in the plant sciences. *HortTechnology Hortte*, *22*(5), 715-718. https://doi.org/10.21273/HORTTECH.22.5.715

Brownlee, K., Parsley, K. M., & Sabel, J. L. (2021). An analysis of plant awareness disparity within introductory biology textbook images. *Journal of Biological Education*, *57*(2), 422-431. https://doi.org/10.1080/00219266.2021.1920301

Canadian Museums Association. (n.d.). *Museums in Canada*. https://museums.ca/company/roster/companyRosterView.html

Capaldi, C.A., Passmore, H., Nisbet, E., Zelenski, J.M., & Dopko, R.L. (2015). Flourishing in nature: A review of the benefits of connecting with nature and its application as a wellbeing intervention. *International Journal of Wellbeing, 5*, 1-16. **https://doi.org/10.5502/ijw.v5i4.449**

Clifford, P., & Marinucci, S. J. (2008). Testing the waters: Three elements of classroom inquiry. *Harvard Educational Review, 78*(4), 675-688. https://doi.org/10.17763/haer.78.4.9134565460145441

Hansen, M. M., Jones, R., & Tocchini, K. (2017). Shinrin-yoku (forest bathing) and nature therapy: A state-of-the-art review. *International Journal of Environmental Research and Public Health, 14*(8), 851. https://doi.org/10.3390/ijerph14080851

Jackson, P. S. W. (1999). Experimentation on a large scale-an analysis of the holdings and resources of botanic gardens. *Botanic Gardens Conservation News*, *3*(3), 27-30. http://www.jstor.org/stable/24753880

Kellington, A. (2011, March 17). Leave no child inside - The importance of field trips. *Americans For The Arts – Artsblog: For Arts Professionals In The Know.* https://blog.americansforthearts.org/2019/05/15/leave-no-child-inside-the-importance-of-field-trips.

Louv, R. (2005). *Last child in the woods: Saving our children from nature-deficit disorder*. Atlantic Books.

Lumber, R., Richardson, M., & Sheffield, D. (2017). Beyond knowing nature: Contact, emotion, compassion, meaning, and beauty are pathways to nature connection. *PLoS ONE 12*(5): e0177186. https://doi.org/10.1371/journal.pone.0177186

Quinton, J., Nesbitt, L., & Czekajlo, A. (2022). Wealthy, educated, and… non-millennial? Variable patterns of distributional inequity in 31 Canadian cities. *Landscape and Urban Planning, 227*. https://doi.org/10.1016/j.landurbplan.2022.104535

HISTORY TEACHING IN A MUSEOLOGICAL SPACE: AN EXPERIENCE AT THE RIO GRANDE DO SUL MEMORIAL, BRAZIL

YURI STELMACH
Feevale University

Abstract

This paper aims to discuss issues concerning the teaching of History in museological spaces, based on the narrative of an experience at the Rio Grande do Sul Memorial, a place that generated the teaching-learning process of students who visited this space. We start from the narrative of the mediated educational action on the itinerant exhibition "Monuments and art: the history of the city at risk", which exposed a series of monuments and public statues taken from the streets of Porto Alegre. By means of these pieces, the mediation sought to reflect on the silenced stories behind those sculptures, aiming to perceive other actors and groups silenced by the patrimonialization process. From a theoretical point of view, it drew on Vygotsky (2010) and Bakhtin (1992), with regard to interactive mediation; Siman (2013), with regard to teaching History through reading the city; and Ramos (2016), on the concept of generator object. Finally, it is believed that the students took possession of plural historical narratives about the city, through the narratives exposed and silenced by the urban historical heritage.

Keywords: History Teaching, Patrimonial Education, Pedagogical Mediation.

Introduction

Breaking down the walls of the classroom to take advantage of other non-formal teaching spaces is a very fruitful alternative with regard to science teaching/learning. And this can happen with the History class, which can take advantage of places of memory in the city, putting students in interaction with historical-cultural artifacts, products of our life in society[4]. Among the different possible learning scenarios, museological spaces – museums, memorials, archives – are important places where visiting students can come into contact with documents, objects and educational actions developed by the institutions themselves, which become generators of processes of teaching-learning.

The objects of material culture displayed in the museum space can be used to build reflections on sociocultural and ethnic-racial relations, historicizing them for their understanding over time. In this way, it excels at building a critical dialogue with the past and its re-signification by individuals in the present. When understood only as a place where ancient objects are contemplated, the museological space misses the opportunity to compose, through educational practices, a critical argument, historicizing the representations of the past in dialogue with the social reality of visitors in the present. The "displacement of the history class" is characterized as an opportunity, together with the students, to articulate "the teaching of History, Heritage Education and criticism of coloniality" (Gil, Pacievitch & Perussatto, 2022, p. 57), in order to expose the plurality of narratives that make up the history and cultural identity of a society.

In this dialogical process, in museums, the mediator acts as an intermediary between the exhibited objects and the critical reflection that aims to come from the students, in a perspective that involves and sensitizes the public to think critically about history through objects of material culture. Bearing in mind that mediation occurs through dialogue between the speaker and the receiver, based on participatory mediation (Bakhtin, 1992), challenges and possibilities arise in this non-formal teaching space, in which knowledge construction is by the students in interaction with the exhibition and the mediator, in a teaching-learning process (Vigotski, 2010).

In this scope, this article has the general aim of discussing issues concerning the teaching of History from the museological space, having the *Rio Grande do Sul Memorial* as the generating place of the teaching-learning process with school groups. Among the many exhibitions held at the Memorial, we opted for the exhibition Monuments and Art: the history of the City at Risk, which exhibited a series of public monuments related to the history of the city of Porto Alegre and the state of Rio Grande do Sul, Brazil. From this perspective, the following problem arises: how is it possible to reflect on the histories of the city and the region by means of the pieces present in the exhibition?

[4] This text is inspired by an article published by the author, in Portuguese, in the journal *Temporalidades* 12 (1), from the Federal University of Minas Gerais, under the title "From the streets to the memorial: monuments, silencing and the teaching of History", 2020.

With this question in mind, we developed an educational action about the exhibition, which is narrated throughout this paper. The elaboration of this educational proposal was made by the author of this text, guided by Professor Caroline Pacievitch, in the context of his training as a professor of History at the Federal University of Rio Grande do Sul [UFRGS], in 2019.

From the works on display, we seek to trigger reflection, along with the students, on the sociocultural processes in the patrimonialization of public objects. Furthermore, we seek to examine how other individuals/social groups – who are not representatives of the white, patriarchal, colonial, and Eurocentric logic – are represented or not in the statuary heritage of Porto Alegre. We start from the teaching possibilities generated by the exposed objects, in the light of Régis Lopes (2004), regarding the teaching of the History of objects, but also that generated through these artefacts of material culture.

In order to stimulate the students' reflection, as well as the debate between them, it was proposed as a final activity that they create a new title for the exhibition, writing it on a poster that had been made available by the mediator. Thus, the proposed final activity was used as the mediator's evaluative object, with the purpose of reflecting on how teaching-learning occurred in the proposed mediation, as well as the pedagogical result in this proposal for teaching History.

Contextualizing the institution, the exhibition, and the monuments of Porto Alegre

The teaching experience narrated in this paper took place at the Rio Grande do Sul Memorial, a space that hosted the exhibition in which the work of pedagogical mediation in the teaching of History was carried out. The Memorial is a large public institution, characterized as a cultural center that houses a museum space of History, Anthropology, in addition to the Historical Archive of Rio Grande do Sul (AHRS). Inaugurated during the year 2000, the Memorial emerged as (Bertin, Endres & Rocho, 2012):

> [...] a cultural institution designed to act as a true showcase of the state of Rio Grande do Sul, a place of memory and dissemination of history and culture from Rio Grande do Sul. In this sense, the house opened up to society with an interactive exhibition aimed at information, research and education through mediation activities and educational action. (p. 639).

Currently, the Institution is open to the public, schools, and universities, with permanent exhibitions and itinerant. Its exhibitions seek to promote reflections on the history and sociocultural identity of Rio Grande do Sul and Brazil, by means of the promotion of museological, artistic, and research activities.

In 2009, the Memorial hosted the special itinerant exhibition Monuments and Art: the history of the City at Risk, which was part of the Cultural Heritage Week of Porto Alegre that year. The exhibition exhibited a wide variety of works of art and public monuments from Porto Alegre, collected by the City Hall due to vandalism, partial theft of their pieces or fear that they would be targets of future depredations. According to its creator and curator, the exhibition

aimed to highlight the importance of public statuary and outdoor art pieces for the history and memory of Porto Alegre. In addition, it aimed to make society aware of the task of conserving and respecting the city's cultural heritage. It was in this exhibition that we carried out the teaching activities narrated in this paper.

Thus, about 25 monuments arrived at the Memorial, which represent and honor personalities and historical events of the city and region, elaborated from the end of the 19th century to the end of the 20th century, materialized in bronze, marble, and cement.

By means of the exhibition Monuments and Art, we reflect on the possibility of going through it with the school groups received by the Memorial, from a critical look at the exposed material culture, from an interactive experience of the students. From this, the opportunity arose to build a dialogue between historical science and art, promoted by mediation with students, in order to bring up reflections on social, historical, artistic, and cultural themes, such as gender issues and racism. From an artistic point of view, it was possible to observe with the students' formal aspects – material, colors, size – in the elaboration of the pieces on display, as well as stylistic aspects.

Without ignoring the objectives proposed by the curatorship of the exhibition, an attempt was made to elaborate an interdisciplinary educational action plan, which allowed visiting students to reflect on the history of the city of Porto Alegre and Rio Grande do Sul, through the mediation between the space, the historian, and the students, based on an interactive and dynamic experience.

We sought to show, during the educational action carried out, that the act of monumentalizing an individual is a choice, usually made by a socioeconomic elite fed by Eurocentric epistemological perspectives. In this way, many other stories and narratives that make up the history of the city are silenced, such as, for example, the perspectives of the black and indigenous populations. Erected in the name of remembering historical processes, events and characters that are related to the memory of the city and the state, as examples or commemoration of something that must be remembered, the public statuary reflects the very way in which the history of Porto Alegre and the collective memory of its inhabitants was represented by public statuary. For a long time, public monuments in cities around the world represented and told unique stories about their nations and societies. According to the Nigerian writer Chimamanda Adichie (2019), a unique story is dangerous because it is stigmatizing and dehumanizing, told by those who hold power. Combating this involves critically reflecting on these stories and disseminating other culturally diverse narratives and experiences, in dialogue with the multiple identities that constitute subjects and life in society.

It is understood that the students' contact with the exhibition pieces, together with the mediation, constituted an opportunity for a critical look and for reflection on the exposed monuments, as well as on the history of the city and its relationship with these sculptures. These monuments are from different eras and, as such, correspond to the values, intentions, and memories of the period in which they were designed and built. In view of this, a critical look at the history of Porto Alegre was sought, using these pieces as objects that generate reflection (Régis Lopes, 2016). If monuments tell a story, one must question what stories they are telling, and what it means to display and silence other narratives.

In the case of Porto Alegre, statuary art goes through some specific moments. In the final years of the 19th century and the beginning of the 20th century, public art in the city was characterized by a style of European, specifically French, trends. Many Brazilian capitals experienced this trend, the result of a series of political, economic, and social (such as the passage from the Empire to the Republic) and, as a consequence, urbanistic transformations. The issue of urban improvements was on the agenda of rulers who sought to organize the city in a controlled and orderly plan of urban and social development, promoting the diversification of available sites for the implementation of monumental constructions, which would become useful for marking and spatial organization of the urban fabric (Marins, 1998). In this way, the squares are decorated with monuments and water fountains, surrounded by an orderly garden work, configuring a public space designed for a bourgeois urban society.

In the final years of the 19th century, Rio Grande do Sul saw the growth and strengthening of the Rio-Grandense Republican Party (PRR), whose rise, in part, came with the fall of the Empire and the Proclamation of the Republic. Having as great exponents the politicians Júlio de Castilhos and Borges de Medeiros, the PRR was responsible for accentuating the positivist ideology in the State, summarized in the movement of order and progress. Positivism, while strengthening the capitalist project of economic and urban modernization of the State, preached conservatism with regard to social changes (Khün, 2011).

In Porto Alegre positivist statuary, according to Doberstein (1995), “literate heroes” were celebrated, in formal attire, carrying a book in their hands or in oratory gestures. His political and intellectual accomplishments should serve as an example for society in Rio Grande do Sul. A great example is the monument in honor of Apolinário Porto Alegre (produced by Alfred Adloff in 1927) and which is part of the exhibition. The work represents the politician as an intellectual: while his left hand supports his chin (under the pose of a thinker), his right hand holds a book. His biography justifies the tribute by the positivist government of the period: a founding member of the PRR, he was a writer, poet, teacher, journalist, and historiographer.

After the 1930s, there is a shift in statuary art in Porto Alegre towards the so-called Gauchismo ideology. With the weakening of positivism and, consequently, the primacy of urban over rural, universal over regional (Doberstein, 1995), public monuments in the city are built with a strong thematic appeal to representations of gaucho culture and the myths of regionalism.

The Farroupilha Civil War became a subject of homage in some works, starting in 1935, the year that marked the centenary of the military conflict, seen as the moment when Rio Grande do Sul rose in arms against the Empire of Brazil, thus marking, the myth of the "gaucho hero", always willing to fight against those who oppose his freedom. To a certain extent, these monuments composed a narrative for the fixation of the idealized figure of the gaucho in the social imaginary of Porto Alegre.

Cultural heritage and history teaching

According to the Instituto do Patrimônio Histórico e Artístico Nacional [IPHAN] (2014), the historical-cultural heritage is conceived as a set of tangible and intangible assets – historic complexes, buildings, constructions, monuments, celebrations, artistic, and religious manifestations –, perceived individually or in its entirety. These sets integrate and are representative of the history, memory, culture, and identity of the different collectivities that form society. It should be noted that the action of considering and institutionalizing a cultural asset as heritage is permeated by social interests and power relations, which configure symbolic, political, and financial disputes between the actors involved in the listing process.

Linked to the preservation of heritage is the so-called heritage education, which is characterized as an educational process aimed at social learning, focusing on cultural heritage. This educational practice aims at ensuring that heritage is appropriated by society, as a resource for the socio-historical understanding of all manifestations that permeate the cultural references of different collectivities that form society (Florêncio et al., 2014). According to Tolentino (2016), cultural heritage is

> [...] conceived as a social element inserted in the life spaces of the subjects, who appropriate it, it must be treated, in educational practices, taking into account its social, political and symbolic dimension. This implies that, in educational actions, cultural heritage cannot be treated as preconceived, in which its value is given a priori, and it is up to the individual to accept this valuation and recognize it as part of their cultural heritage. (p. 47).

With this, the author explains that, when carrying out educational actions on cultural heritage, one should start from a critical reflection on the reasons considered for the patrimonialization of a certain cultural asset, also taking into account its insertion in a certain historical time. In addition, the author points out that educational practices around heritage must recognize the game of forces existing in the process of selection and appropriation of heritage elements, highlighting the divergences and conflicts in this "struggle between memory and oblivion" (Tolentino, 2016, p. 47).

Bearing in mind the dichotomous relationship between memory and oblivion, the pieces displayed in the exhibition Monuments and Art made it possible to reflect with students on which elements, individuals, histories and memories of the city were (and are) being monumentalized and which are being silenced. Through this reflection, we tried to understand

how the monuments were used for the preservation of a certain memory that corresponds to the social portions of the urban elite. By means of the heritage education action plan - focusing on the diversity that forms the city's history -, the educational action designed for the exhibition aimed to (Tolentino, 2016):

> [...] dialogical and democratic process of this educational practice, in a freirian perspective, which values otherness, respect for cultural diversity and the active participation of producers and heritage holders as socio-historical subjects. (p. 40).

It should be noted that the critical approach to the pieces was carried out taking into account the historical and social context in which they were produced, trying not to fall into an anachronistic interpretation of the monuments. From this, it reflected on the monuments that are being produced and occupy the urban space in the present time, the continuities and discontinuities of the aspects that guide the process of public monumentalization.

One of the objectives in relation to the proposed mediation plan for the Memorial was to permeate the history of Porto Alegre through the objects on display, putting students in direct contact with the pieces present there, and striving for reflection on the history of the city. By means of this contact, the sensitive of visitors is encouraged to observe the characteristics that materially form the monuments: the way they represent something/someone, the material they are made of, size, weight, damage suffered, and the paths taken along the way. time, until they reach the exhibition. In accordance with Régis Lopes (2004, p. 22), a "History of objects" was therefore sought, which presupposes the study of "History in objects", that is, having objects – material culture – as a source reflection of society, since they are indications of cultural traits. In this sense, the pieces on display at the exhibition were used as a "generative object", which aims to (Régis Lopes, 2004):

> [...] motivate reflections on the plots between subject and object: to perceive the life of objects, understand and feel that objects express cultural traits, and that objects are creators and creatures of human beings. Now, such an exercise must start from everyday life itself, as this is how dialogue is established, knowledge of the new in lived experience: conversation between what is known and what is going to be known – reading objects as an act of seeking new readings. (p. 73).

Taking the material goods on display as generating objects, together with the mediation with the students, allowed us to reach broader layers of analysis, starting from the objects. This educational approach in the museological space enabled the integration between art and human sciences, especially historical science. From the students' interaction with the monuments on display – that is, what was visible –, it was possible to reflect on what was invisible, silenced by the objects. In this sense, the students were asked, where are the statues that represent the women of our history? Where are the black, indigenous people? Is our history just a white and Eurocentric narrative? These questions about what was not represented generated reflections beyond the exhibition, contributing to a critical look at multiple aspects: artistic and historical

doing, national and cultural identity, the history of the city etc. In this way, we believe that the intersection between students, mediation, objects and the museum, allowed to reach other perspectives of learning and knowledge, beyond the traditional classroom of History.

That said, with regard to the educational action proposed for the exhibition, it turns to teaching-learning issues, since the function of the mediator in a museological space is to inquire, question, that is, to encourage reflection through those exposed objects. After all, the mediator's relationship with the students is an exchange of knowledge, given that they are in a dialogical relationship.

With regard to teaching-learning, Vygotsky (2010) explains that, in order to consider the development of the subject, it is necessary, concomitantly, to take into account the history of the society in which he is inserted. Therefore, the author argues that the way in which the educator tries to transmit his knowledge to his students affects the learning process of the students, since the subject is in an exchange relationship, through which he transmits his thoughts, experiences , culture etc.

In the case of mediation, when addressing figures from Porto Alegre society to the students, not only focusing on the figures exposed in the exhibition, bringing silenced stories behind those already brought, we tried to include the student in the history of their region, their society. And that, in the light of Vygotsky (2010), contributes, or is expected to contribute, to the development of those students. This is a way of bringing a silenced history of Porto Alegre: black, indigenous, seeking a plural and democratic history teaching, fleeing the problems brought by a unique and elitist history of the city.

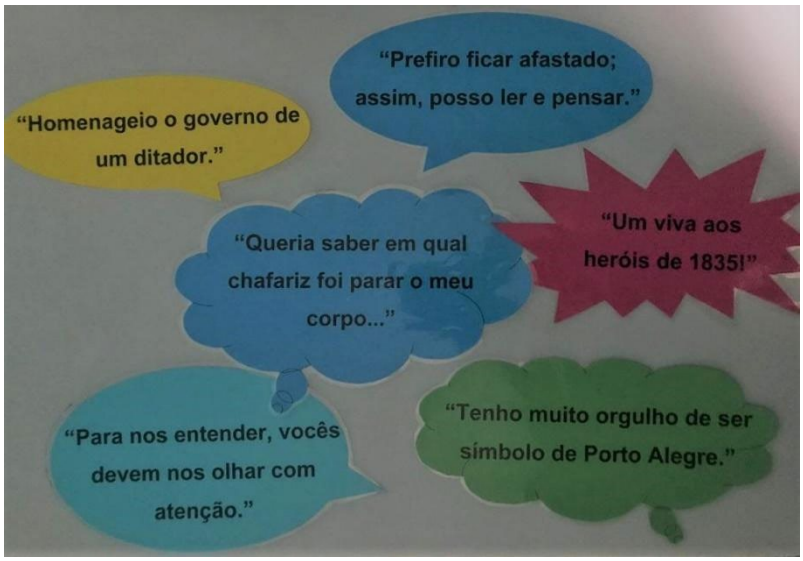
For Bakhtin (1992), mediation is seen as an interlocution between the mediator and the students, taking into account the context and class situation of each individual. Furthermore, mediation goes beyond exposing themes; it, in the light of Bakhtin (1992), seeks to build meanings and reflections between the exhibited objects and the public, in their interaction with the mediation of the Institution's educational action. In this way, the mediator (Régis Lopes, 2004):

[...] it should not expose the exhibition, but provoke, in visitors, the desire to see objects. In the case of school groups, work alternatives assume certain specificities. Instead of guiding the visit by giving explanations, the monitor can challenge the students through exercises that will be carried out from the contact with the exhibition. Now, this allows the student to discover that museums are sources of knowledge - it opens access routes to cognitive fruition, as he himself becomes responsible for the act of responding to the provocation posed. (p. 25).

Thus, for the present mediation to take place, based on the above postulates, an initial moment was developed with the students, through which it was possible for them to freely enter the exhibition, building their own initial perspectives.

To this end, at the beginning of the mediation, the students were divided into small groups, at which point each group received a plaque. These objects had a small caption, which represented a speech, or a feeling expressed by the monument. The use of the plates provided a very dynamic creative exercise on the part of the students, promoting their free interactions with the exposed objects. Figure 1 below shows the material used.

Figure 1. *Signs prepared and used in the activity*



Note. Author's photograph.

The objective was to mobilize the students to walk around the place, observe the exhibited pieces, allowing them to appropriate the exhibition space. It is believed that reflection on the phrases, in dialogue with the pieces, allowed an initial curiosity to be triggered about the exhibition, allowing the students' feelings to flourish about what was being seen by them. For the initial and final activities of the mediation, it was decided to use materials that encourage students to participate in the proposed dynamic. In this way, materials were used that, in a creative way, invited students to act (SIMON, 2012), in a space of history and memory that values the active participation of its visitors.

With the aim of illustrating the mediation and reflections arising from the students' visitation that took place in the exhibition, it is necessary to delve into some of the monuments that made up the exhibition. The guiding thread of the mediation ran through various moments in the city's history and through the ideas that guided both the urban plan of Porto Alegre and the relationship between the works and the socio-political context in which they were produced. The guided tour was structured so that students could observe chronologically the artistic and ideological differences that guided the making of the pieces, as well as the historical characters represented, within the historical context of the city of Porto Alegre. It should be noted that, in some exhibited pieces, it was not possible to obtain much information about their specificities, such as the request for manufacture, authorship or opening ceremony.

Thus, the journey began with pieces dating from the turn of the 19th to the 20th century, which were part of an urban process based on models of European capitals. Examining the works *Estátua do Rio dos Sinos* (imported from the region of Carrara, Italy) and *O Menino da Cornucópia* (manufactured by the Louis Thiriot foundry, in France), the students were invited to talk about the elements that made up the pieces. Among the speeches, they exposed themes from Greco-Roman mythology, as the Statue represents a nymph, while the Boy is, in fact, a triton (his legs give way to flippers), messenger of Poseidon, Greek deity of the seas and oceans. Originally, both pieces were part of sets that formed fountains in squares in Porto Alegre.

Separated from the other pieces in the exhibition, the students came across the bust in honor of Apolinário Porto Alegre (made in bronze by the German Alfred Adloff, in 1927). This piece can be characterized as a "booklet" of the positivist ideology widespread in the period. When briefly approaching positivism with the students, they were asked how this ideology approached the plastic language of the monument. Almost unanimously, the students highlighted the intellectual pose in which Apolinário was represented: while the chin is supported by one hand, the other holds a book, as if the character was reflecting on something he had just read.

Another piece is a bronze plaque, by Alfred Adloff (1928). It was dedicated to the then mayor of Porto Alegre, Otávio Rocha, in the context of the opening of Avenida Júlio de Castilhos. A double homage resides in this piece. In the left corner of the plate, there is a male figure, sitting on a phrase in French: *les grandes hommes / sont les phares / de humanite* (great men are the beacons of humanity). Visitors were asked about possible interpretations of this phrase, bearing in mind those honored in the play (both men and politicians) and the positivist ideology, for which history is a showcase for admiration of deeds and "great men", "heroes" from the past.

Moving on to the monuments created after 1930, one can see the characteristics of a moment in which the positivist ideology in decline merged with the concept of regional art, called gauchismo. It was a period in which state and municipal personalities and exponents of the Farroupilha Civil War were monumentalized, due to the celebration of the 100th anniversary of the conflict, in 1935. The exhibition included a metal plaque from the Sírio-Libanês Obelisk, donated by the Syrian-Lebanese community in honor of the farroupilhas (Alfred Adloff, 1935), as well as the plaque on the monument to Bento Gonçalves (Antônio Caringi, 1935), dedicated to the soldiers who fought in the conflict. They are relatively simple pieces, plastically composed of a text, in hollow letters, on the metal piece.

Despite the visual simplicity of the pieces, they allowed us to reflect on the memory of the Farroupilha Civil War in the history of the region. This was one of the most interesting moments of the mediation, as the students' brought questions based on prior knowledge about the conflict. A seventh-grade student sked about the reasons for commemorating, in Rio Grande do Sul, a war that, in fact, was lost by the State. Contextualizing the conflict opened up the

possibility of problematizing individuals who are monumentalized/honored to the detriment of other historical characters/collectives such as, for example, the body of Lanceiros Negros.

The last two monuments inserted in the mediation are, in fact, two representative models of their originals. The first, a bronze statue of the Laçador (Antônio Caringi, 1954); the second, Monument to the Açorianos, built with iron plates by Carlos Tenius, in 1973. Originally located next to Salgado Filho Airport, measuring more than 5 meters in height, the Laçador displayed in the exhibition results from a 3D print of approximately 2 meters. The scanning and printing work was carried out by the Materials Selection and Design Laboratory of the Federal University of Rio Grande do Sul [LDSM/UFRGS]

The piece represents a male individual, serious physiognomy, strong, erect and haughty body. According to Alves (2005), the traditionalist movement wanted, for the city, a representative symbol of what they imagined as the gaucho identity, which Caringi sought to translate in his work. Since 2001, the monument is listed as historical heritage of Porto Alegre. At that moment of mediation, it was possible to reflect on the interaction between art, monumentalization and technology, due to the presence of the 3D model made by the LDSM. The exposed model allowed to expose together with the students how the areas of Design and Engineering can be used in favor of the preservation of the historical and cultural heritage, promoting the identification, conservation, as well as actions of exhibition and dissemination of the historical and cultural heritage. Thus, it was possible to conclude with the classes that the area of History and Historical Heritage does not only concern “old things”, in fact, maintaining a close interdisciplinary dialogue with technological and engineering areas.

Regarding the Monument to the Açorianos, the exhibition features the iron model used as a prototype of the original monument, which is located in Largo dos Açores, in Porto Alegre. Measuring approximately 2 meters in length by 1.5 meters in height, the model presents itself as a large sculpture, which retains the markings, in its structure, of the professionals who created it. With regard to its dimensions, its original is considered the largest public monument in the city, being inaugurated on the anniversary of Porto Alegre, in 1974. Through futuristic and abstract features, the plastic language of the monument was designed to represent the first couples who came from the Azores archipelago (Portugal), in the second half of the 18th century, with the aim of populating the region where it is currently located Porto Alegre. Therefore, it is a piece built to represent the “founding myth” of the city.

Even though the Laçador portrays only one individual and the Monument to the Açorianos represents a group of individuals, in both, there is a depersonalization of the honorees, using the expression of Marins (1998-1999). The Laçador is an individual who represents the gaucho collective, which should serve as an identification for all who share this identity, however “mythical” it may be. The Monument to the Açorianos, in turn, displays a series of individuals, without faces or clothing, who are guided by a winged figure that points to the other side of the Atlantic. The play conveys immigration, the horizon of expectations turned to the

beginning of a new life on Brazilian soil. The abstractionism of the piece allowed, on the part of the students, different interpretations about what is seen. While some saw the piece forming a caravel, others focused only on the winged being, identifying an angel or a bird. With this, the possibility arose for students to perceive one of the artistic functions of sculpture, which is to cause strangeness and allow a myriad of interpretations of its plastic language.

Thus, the students' contact with the pieces in the exhibition constituted an opportunity for reflection and reading of the exposed monuments and their relationship with the city's history, as they were made for the urban space and public appreciation. Monumentalizing a symbol or an individual presupposes an intention, in this way, those pieces are vestiges of social and cultural manifestations of a certain historical context of Porto Alegre. The statues can be seen as documents for the interpretation of the past, linked in a history-process perspective. (Alves, 2015).

For Siman (2013), the city is a text to be read through the objects that constitute it. The author argues that the understanding of history in the reading of the city-text goes through the observation of its words, signs, objects, and landscape of urbanity. It is through this reading of the elements that form the urban space that the possibility of a re-reading of the history of the city and the individuals who inhabit this space opens up, whether in the centers or on the margins. Thus, the author emphasizes the need to develop sensibilities for the historical observation of the city, that is, looking beyond what is seen. In addition, it requires curiosity from the observer "[...] for the layers of time that are declared and indicated in their materiality and symbology" (Siman, 2013, p. 5). In methodological terms, the great challenge in reading the city (Siman, 2013):

[...] it is to reveal what is hidden through an archeology of the text/fabric about the urban that seeks to expose what is not perceived in a territory always transformed by new buildings, new layouts, new social actors, and new uses. An archeology that can make use of documents that secrete traces and marks of what can no longer be seen. (p. 5).

In this sense, an attempt was made to characterize the exhibited pieces as documents of the city's past, reflecting together with the visiting students the histories of the city through the pieces. For example, when observing the statues of Rio dos Sinos and the Menino da Cornucópia (both from the 19th century), the Eurocentric influence is reflected in the context of urban improvements in the city of Porto Alegre. In addition, an attempt was made to bring to the group reflection that the passion for the urbanization of the city center was marked by a racist and hygienist urban plan, in a historical process of marginalization of the black communities that inhabited the city center. These pieces are the result of a context – which started at the end of the 19th century and continued into the 20th century – where the black population of former slaves was pushed to the outskirts of the city and away from the urban center of the capital of Rio Grande do Sul, a territory that historically identified this population. The same reflection was

proposed to the students when observing the bust of the positivist Apolinário Porto Alegre and Otávio Rocha, former mayor known as "the reformer", due to the public works he carried out.

The absence of female personalities in statuary art was observed by students in the seventh year of Elementary School. These, when they appear, were identified with generic terms (the nymph, the statue of Rio dos Sinos), but never representing a real character, political and heroic personality of the city's history. Finally, the example of the most recent piece that was on display, the Monument to the Açorianos (1973), still fits. This piece portrays the arrival of couples from the Azores Island, in Portugal, in 1752, which is considered a founding feat of the current city of Porto Alegre. At this moment of mediation, the students were asked about the existence of other communities prior to the Azoreans and the reasons why they were not considered in the official history of the city. Such history does not consider the indigenous communities that inhabited this territory before the European arrival in the region. Seventh grade students pointed out the lack of monuments in honor of black or indigenous personalities, collectives.

Thus, in the "Monuments and Art" exhibition, the possibility of using objects as a source for reflection was seen, making use of the pieces to delve into the stories that have yet to be addressed. According to Knauss (2010), the critical argument about the artistic beauty of a piece can question not only the form, but the reading of the history carried out by the monument, that is, an interpretation of the past preserved there. Through this, the objective was to pluralize the history of Porto Alegre, reflecting on the different cultures and communities that form it (Siman, 2013):

There are parts and stretches of the city that are more visible and/or are the ones our eyes were trained to see. There is a city that is more visible than invisible, a city that exposes itself and imposes itself on the eyes of the city dweller: the monuments, the houses of power and the power of memory. Observing monuments as documents is a condition for understanding their perennial intentions. Monuments/documents built with solidity capable of defying the passage of time, the natural weather, allowing themselves to be touched and reinterpreted by successive generations, witnessing the speeches, power struggles and aesthetic taste that are reconstructed throughout history. (p. 8).

The mediation carried out also allowed the students to reflect on the function of public monuments and that the choice of themes, individuals and monumentalized facts is not neutral, but the result of collective choices of a certain social class.

(Re)creating the title of the exhibition

After walking through the monuments, it was proposed to the students, based on the reflections arising from the mediated educational action, that they recreate the title of the exhibition. It is highlighted, in the pages above, the need to reflect on which stories are being told by urban monuments. These were made to show presence and pay homage to people, symbols and deeds, but also reveal absences. At the end of the mediation, the students returned to the title of the exhibition – "The history of the city at risk" –, inviting them to a critical dialogue with it through the following questions: does the exhibition cover the entire history of city? Thinking about the history of Porto Alegre known to you, which figures are not represented here? The first intention was not to criticize the title of the exhibition, but to use it as a trigger for the resumption of the reflection carried out during the mediation.

When these questions were raised, it was possible to discuss with the students the ways in which it became monumental – considering the historical context in which those pieces were produced – and how this practice is carried out in contemporary times, triggering a reflection on how others individuals/social groups currently appear or not in the city's statuary heritage. From this, some students brought the example of the Museu de Percurso do Negro, which revealed the presence of black communities in the center of the capital through spaces and religious and cultural symbols of this population. In order to resume, perceive and document the students' learning, it was proposed that they recreate the title of the exhibition, bearing in mind the questions posed earlier and the reflections built during the mediation. For this, the students formed small groups to carry out the activity, for which cardboard and colored pens were made available for writing.

Below are some examples of the titles they created. It should be noted that, in each mediation, the groups created more than one title on each poster, because they changed it based on internal conversations in their group, as well as guiding questions from their teachers and the mediator. It should also be said that all titles are authored by the students, without the direct intervention of other people - teachers, mediator.

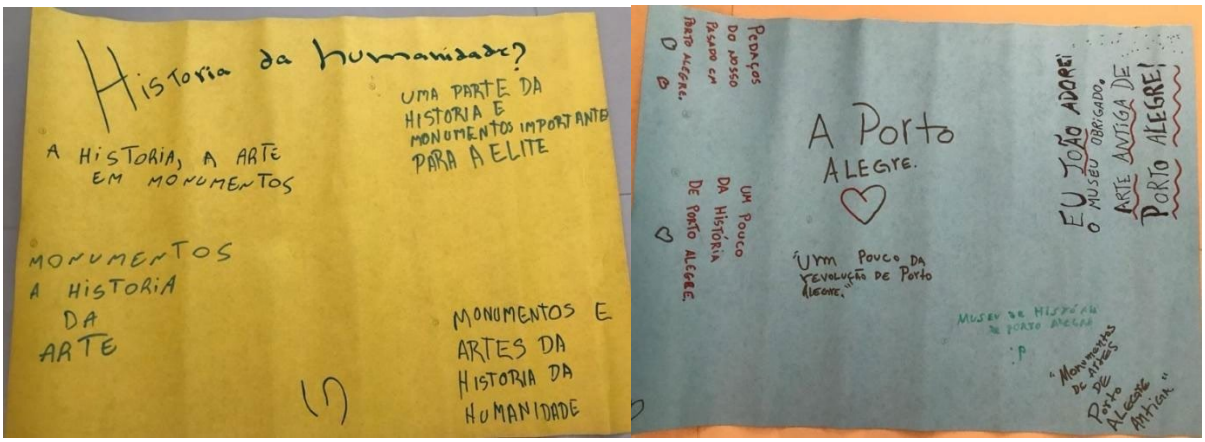
The first mediation took place on September 25, 2019, when a seventh-grade elementary school class was received. Despite being a small class (8 students), it needed a greater incentive to carry out the activity. The first title created by them was "Monuments and art: the history of mankind", which continued in accordance with the original title of the exhibition.

From this, it was necessary to launch small questions for the group to reflect and develop a title that would account for what had been discussed in the mediation. Thus, the titles emerged (Figure 2): "A part of history and important monuments for the elite"; "A bit of the history of Porto Alegre"; and "Pieces of our past in Porto Alegre". It was noted that the last titles are very different from the first, and words like "a little", "a part", and "pieces" explain that the students reflected and understood that those exposed monuments did not handle the plurality of narratives that form the history of the city, but only a part of it. In addition, by putting "important for the

elite" in a title, one of the groups exposed its understanding of the social group responsible for the monumentalization of some pieces, revealing the understanding that those symbols and individuals were not chosen in a neutral way for the statuary elaboration, being involved in social relations of power.

We also emphasize the permanence of the word "art" in the elaborated titles. When going through the exhibition, the artistic aspect that involved the elaboration of the monuments was highlighted, in an interdisciplinary learning between the disciplines of History and Art. Through the exposed statuary repertoire, it was possible to highlight aesthetic aspects to the students, as well as the transformation of these characteristics and artistic models over time.

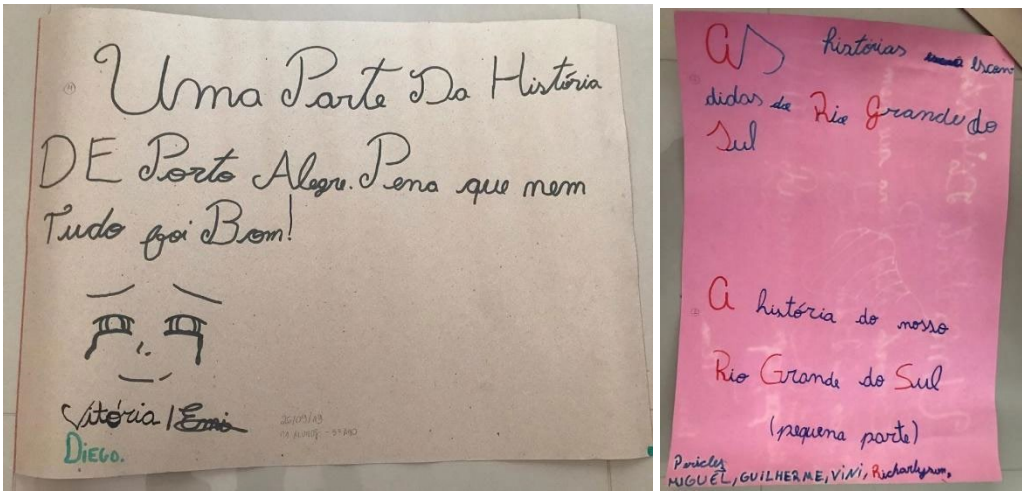
Figure 2. *Posters created by seventh grade students*



Note. Author's photograph.

In the second mediation, there was the participation of 11 students from a fifth-grade elementary school class, on September 26th. Among the titles, two stand out, which are in line with the reflection proposed in the mediation (Figure 3): "The hidden stories of our Rio Grande do Sul" and "A part of the history of Porto Alegre. Too bad it wasn't all good.". The first strongly brings the word "escondidas", which concerns the stories beyond the monuments exhibited there, but which were triggered by those pieces. The second title, in turn, as in the first mediation, brings the expression "a part", also showing that the exhibition brought only a piece of so many episodes and figures that make up the history of Porto Alegre. Still in this title, one can see almost a type of lamentation expressed by the students in the phrase "too bad that not everything was good". It is believed that this occurred because the other stories, other than those of an urban bourgeois elite, are permeated by reports of resistance, social and cultural marginalization, struggle for rights, etc. During the mediation, these concepts were addressed and discussed with the students when the monuments were related to the aspects that led to the dispossession of the black community – enslaved and formerly enslaved – from the city center. We tried to exemplify this situation not only with the reality of Porto Alegre, but also showing that this type of government policy was – and continues to be – a reality in other Brazilian capitals, such as São Paulo and Rio de Janeiro, for example.

Figure 3. *Posters created by fifth grade students*

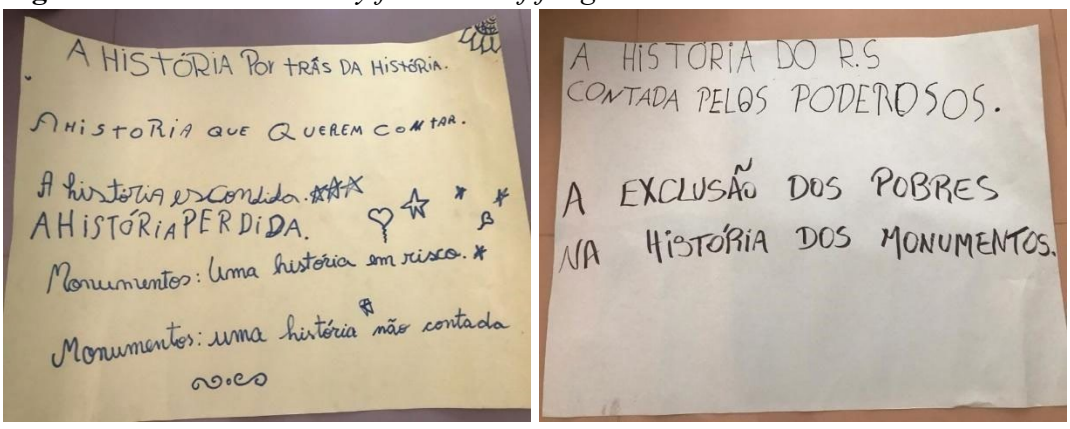


Note. Author's photograph.

Finally, the third mediation took place on September 27, with 16 fourth- and fifth-year students, concomitantly. In this mediated visit, the most marked titles emerged regarding the intentionality of monumentalization. The following titles stand out (Figure 4): “The story they want to tell”; “The history of RS told by the powerful”; “The exclusion of the poor in the history of monuments”; and “Half of Rio Grande do Sul in its history”.

Throughout the mediated journey, an attempt was made to emphasize the intentionality in the creation of a monument, in view of its historical context. This was done with the intention of reflecting on the non-neutrality of monumentalization. The exhibited pieces were treated as document-monuments, that is, exposing the monument to historical analysis, criticism, reflection and showing students that that fact or individual, represented in stone, bronze, or iron, was chosen to be there. It was shown, therefore, that the silences, to a certain extent, are also intentional.

Figure 4. *Posters created by fourth and fifth grade students*



Note. Author's photograph.

These phrases elucidate the importance of reflection through the objects in the exhibition. It can be seen, in fact, that the pieces shown in the exhibition do not cover the entire history of Porto Alegre. This reflection is important for us to think about the discipline and the History class, in general, which must account for the plurality of narratives that form our history and our culture. Such possibilities have a direct impact on socially constructed cultural representations, as well as on our subjectivities, within which we build our individual and collective identities.

In addition, they reveal that there was a reflection on the part of the students about the intentionality of the act of monumentalizing, which was guided by the interests of a social and political elite – "the story they want to tell" –, passing through the "exclusion of the poor".

Final considerations

The students' contact with the exhibited pieces, through the proposed reflections, can lead students to other questions about the urban space where they live, rethinking the symbols, personalities, events, cultures that were and are being chosen to remain in the collective memory of the city. After all, what do monuments say about us and our history? The reflections carried out by the students during the mediation also allowed thinking critically about the different narratives that dispute the symbolic space in the cultural heritage, in addition to the need to rethink the signs and symbols that are projected in Porto Alegre.

From the mediation carried out, it was found that the students took possession of a critical look at the exposed objects. An example of this observation was that of a student who, while observing the monuments in honor of the Farroupilha Civil War, asked the mediator why Rio Grande do Sul commemorated a war in which it had been defeated. Another example was the questioning about the lack of female characters in public statuary, an absence perceived as a result of a culturally patriarchal society. In these examples, it is evident that the students' criticality was fostered by contact with the monuments and by the mediation process.

Moving the history class to the space of the museum made it possible to streamline the teaching-learning process, through the approximation and interaction of students with the exhibited pieces. Learning was built together with the students, by means of an interactive experience with the exhibition. In addition, it was possible to work with interdisciplinary issues, such as: (i) the approximation between the disciplines of history and art, focusing both on the historicity of monuments and the formal and artistic aspects of their materiality – materials, colors, styles; (ii) the interaction between heritage, art and 3D technology used in the conservation and dissemination of historical and cultural heritage.

Through the titles created by the students, it is believed that the reflections proposed during the mediation allowed the students to take possession of a more plural history, which is permeated by a series of disputes and social inequalities. It is understood, therefore, that this meets the objectives that guide actions in Heritage Education, which aim at the socio-historical understanding of individuals through a social, plural and democratic learning of human

collectivities. With this, we hope that students have become aware of the ethnic-racial plurality that permeates our history, which cannot be reduced to a single narrative.

References

Adiche, C. (2019). *O perigo de uma história única*. São Paulo: Companhia das Letras.

Alves, F. das N. (2015). Estatuária, patrimônio histórico e ensino de história: o caso do monumento ao Barão do Rio Branco na cidade de Rio Grande. *Historiae*, *6*(2), 167-212.

Alves, J. F. (2005). Inventário da escultura pública de Porto Alegre. In M. A. Bulhões (Ed.), *Memória em caleidoscópio: artes visuais no Rio Grande do Sul* (pp. 135-160). Porto Alegre: Editora UFRGS.

Bakhtin, M. V. (1992). *Marxismo e filosofia da linguagem: problemas fundamentais do método sociológico da Ciência da Linguagem*. São Paulo: Hucitec.

Bertin, S., Endres, R. & Rocho, L. (2012). Memorial do Rio Grande do Sul: recuperando práticas educativas. *Aedos*, *4*(11), 638-651.

Doberstein, A. (1995). Escalada, Caringi e o gauchismo na estatuária. In E. Clemente (Ed.), *Integração: Artes, Letras e História*. Porto Alegre: EDIPUC.

Florêncio S. R., Clerot, P., Bezerra, J. & Ramassote, R. (2014). *Educação Patrimonial: histórico, conceitos e processos*. Brasília: IPHAN.

Gil, C. Z. de V., Pacievitch, C. & Perussatto, M. K. (2022). Pensar historicamente com a educação patrimonial: um não guia. *Sillogés*, *5*(1), 56-87.

Instituto do Patrimônio Histórico e Artístico Nacional. (2014). *Patrimônio Cultural*. Brasília: IPHAN.

Knauss, P. (2010). A interpretação do Brasil na escultura pública: arte, memória e história. *Revista do Instituto Histórico e Geográfico Brasileiro*, *171*(449), 219-232.

Kühn, F. (2011). *Breve História do Rio Grande do Sul*. Porto Alegre: Leitura XXI.

Le Goff, J. (1990). Documento/Monumento. In J. Le Goff (Ed.), *História e Memória*. Campinas: Editora da UNICAMP.

Leme, M. C. da S. (2001). Urbanismo: a formação de um conhecimento e de uma atuação profissional. In M. S. Bresciani (Ed.), *Palavras da Cidade*. Porto Alegre: Editora da Universidade/UFRGS.

Marins, P. C. G. (2003). O Parque do Ibirapuera e a construção da identidade paulista. *Anais do Museu Paulista*, (6/7), 9-36.

Régis Lopes, F. (2016). Objeto gerador: considerações sobre o museu e a cultura material no ensino de história. *Revista Historiar*, *8*(14), 70-93.

Régis Lopes, F. (2004). *A Danação do Objeto: o museu no ensino de história*. Chapecó: Argos.

Siman, L. M. (2013). Cidade: um texto a ser lido, experenciado e recriado, entre flores e ervas daninhas. In S. R. Miranda, L. M. Siman (Eds.), *Cidade, Memória e Educação*. Juiz de Fora: Editora UFJF.

Simon, N. [TEDx Talks]. (2012, November 7). *Opening up the Museum: Nina Simon @ TEDxSantaCruz* [Video]. YouTube. https://www.youtube.com/watch?v=aIcwIH1vZ9w&t=386s.

Tolentino A. B. (2016). O que não é educação patrimonial: cinco falácias sobre seu conceito e sua prática. In A. B. Tolentino, E. Oliveira (Eds.), *Educação patrimonial: políticas, relações de poder e ações afirmativas* (pp. 38-48). João Pessoa: IPHAN-PB.

Velho, G. (2016). Patrimônio, negociação e conflito. *Mana*, *12*(1), 237-248.

Vygotsky, L. S. (2010). Aprendizagem e desenvolvimento na Idade Escolar. In L. S. Vigostky, A. Luria, A. N. Leontiev (Eds.), *Linguagem, desenvolvimento e aprendizagem*. São Paulo: Ícone

STUDENT VOICES

CELL DEATH & CERTAINTY

DIYA MUKHERJEE
Rockefeller University

Abstract

I am Diya Mukherjee, a high school senior based in San Jose, CA with an interest in computational biology and public health. The summer of 2023 marked a turning point for me that is familiar to any science student: my first wet lab experience. I was given the incredible opportunity to participate in the Summer Science Research Program (SSRP) at Rockefeller University in New York, NY, and work with research mentors from the Fuchs Lab of Mammalian Cell Biology and Development on a project about the role of inflammation in skin cancer. Cell Death & Certainty depicts an incident from my third week of the program, in which many of my cell samples began to mysteriously die overnight. I deliberately wrote the story with a melodramatic tone because I think that science so often feels that way.

They were all dead.

Time of death: Sometime in the last 24 hours.

Cause of death: Unknown.

I squinted with one eye through the microscope and observed the graveyard of cells in the cell plate, each adopting an inky blue color, announcing their journey to the underworld. Although the cells had most likely died because of an equipment malfunction, I still felt a level of personal responsibility. I had failed the tiny units of life that had depended on me as their caretaker.

The dying cells were one of the many setbacks in my scientific project during my time interning with the Summer Science Research Program (SSRP) at Rockefeller University in New York, New York. As my first in-person research experience, this internship was everything to me: I knew I had no choice but to "do the science correctly," to eliminate any possible source of error and to account for every single variable. My pipetting, a method of transferring cells, had to be immaculate, and my procedure had to be airtight. I refused to be the person with scattered, inconclusive results. Precision, I determined, was the key and point of validation to my work.

Walking back home that day, I watched New York's cloudy Manhattan sunset, and I was determined that today's failure would never be repeated. My trial run at perfection had ended today; the next morning would be the real thing. The next morning is when I will be *that* scientist.

I was greeted the next morning at Rockefeller University by a cluttered cell culture laboratory and a song by Canadian rapper, Drake, playing on the radio channeled through a Bluetooth speaker. My peers had already begun processing their cell samples, and they welcomed me with hopeful smiles and pats on the back. Still, a lull in the chatter told me they were suffering from similar doubts about the cell samples. Would our new cells live, survive? Or would they suffer the same fate as their predecessors?

I walked towards the bench and cell incubator, pulled out my cell culture plates. I was nervous but I carefully placed them under the microscope. A swarm of blue coloured the magnification field. The blue colour answered my question. My face fell as I shifted the scope to focus on different parts of the cell plate. Blue, I found. Blue. Blue. Blue. With each shift, I observed the mass death. I was convinced: any hope of scientific discovery was lost.

My research mentor passed by my laboratory space.

"Need any help?" she asked, and I knew what she was really asking me.

"They're all blue," I told her with an upsetting tone in my voice, "I can't see any living cells in the microscope."

I shifted over to let her look down at the lens to confirm my results. She paused for a minute, looked at me with a thinking look.

"Have you written it down in your notebook?" she asked.

"No," I replied promptly, "There's nothing living to note down."

She laughed. "You're too used to classroom science, Diya. Write down the possible sources of cell death in your notebook. You can even count the number of dead cells too to see what you can learn."

I was taken aback. New possibilities popped into my head: What if the cell incubator had failed? Or perhaps, the cell "food" accidentally had a harmful chemical in it? Or, maybe, I hadn't cultured the cells properly to begin with.

I stared at my notebook, hesitant to write my ideas down. It felt like I was accepting failure. At the same time, acknowledging the error felt liberating, like a step forward after hitting a wall.

I sighed.

"This is frustrating."

My mentor shrugged her shoulders casually. "Welcome to research," she said.

TACKLING DEMOTIVATION IN STEM FIELDS: A STUDENT'S PERSPECTIVE

KAVYA M. PANDRANGI
First Year Undergraduate, University of California, Los Angeles

Abstract

The fields of STEM/STEAM are ones in which curiosity and creativity meet a very high level of rigor. When navigating such a field, staying motivated and maintaining belief in oneself and one's intelligence can prove difficult. Self-doubt and discouragement quickly creep in for many students, as they did for me at times. In this piece, I give an account of my STEM journey, from high school chemistry to science fairs, the challenges and disheartening moments that I faced, and the growth and inspiration that came out of them that I take with me as I begin to pursue a career in STEM.

Keywords: STEM Education, motivation, Science Fair, Science Education

My story

I have always wanted to be a doctor. Even from childhood, when I would be asked if I would become a software engineer like my mother and father (and the rest of my family and relatives for that matter), I would shake my head, saying that I would one day become a doctor. As a result of this dream, science was always a favorite subject throughout elementary and middle school. I would breeze through any worksheets or labs I was given during science classes, whether it was biology or physics. I spent my free time working on my anatomy coloring books and reading science fun facts in *Weird but True* books. Naturally, I assumed that this trend of success in STEM would continue, as I started high school in one of the most competitive and STEM-focused schools in my state. Then came grade 10 honors chemistry. Despite my grip on the subject through elementary and middle school, topics such as molecular geometry, thermodynamics, and stoichiometry flew right over my head. For the very first time, I was completely lost in a science class. I watched in horror as others grasped the concepts immediately and earned the "A" grades that I once got while I was left with "B"s and "C"s. I found thoughts such as "Was I actually not good at science?" lingering at the back of my head and started telling myself "Maybe I shouldn't go into medicine if I don't understand simple chemistry." As discouragement creeped in and my grades dipped, I was finding it hard to stay motivated in this rigorous field.

Soon enough, however, inspiration struck. Despite my doubts about pre-med at this time, I was continuing my pre-med extracurriculars. This time, I was shadowing a physician in a pediatric clinic. I had been shadowing this physician for a while now, so I was intrigued when I saw a doctor that I hadn't seen in the clinic before at her desk. For the sake of networking and as well as for my own curiosity, I decided to introduce myself to her. From the moment I started talking to her, she was warm, friendly, and clearly knowledgeable – exactly the kind of doctor I wanted to be. She was a family medicine doctor practicing at this small San Jose clinic, and as we talked, I discovered that she was actually a refugee from North Korea. She had bravely traveled the 9000 kilometers alone. She told me that upon arriving, she too was, although exhilarated, feeling discouraged in this new country. She told me, however, that she ended up finding support and inspiration in her medical school advisors. She worked hard with them as her support and inspiration to get through medical school and residency. Now, she is not only a doctor, but a very successful one in her practice.

This interaction really put it all into perspective. If she could go through such hardship and demotivation and still succeed in this field, then why couldn't I? Going through honors chemistry didn't seem so bad at that moment. From that moment, this physician became my silent mentor – a reminder that I could get through any difficult class, project, or job that was thrown my way. I gained inspiration and confidence in science from that moment, not from studying harder or from reading textbooks, but from a person and her story.

As inspired as I was, however, moments of discouragement in fields as rigorous as STEM are inevitable. Since grade 6, I have been quite good at science fairs, earning grand prizes, first place awards, and nominations to the state and national science fairs. With this strength in mind, I decided to again participate in the science fair in grade 10. I not only worked hard, but I went out of my comfort zone in science to code a virtual reality app to be used in hospitals. I proudly presented this app to the judges and seeing the smiles on their faces, I was sure that I would once again earn 1st prize. A month later I received my prize packet, and eagerly opened it. I reached in, however, to find, not a first-place medal, but a ribbon for honorable mention. Despite that still being quite an accomplishment, I was crushed. Why was I not good at science fair anymore? But amidst this sadness, an idea struck. Why should I be discouraged by a high school regional science fair? The next day, I decided to instead submit my project to two national level conferences, one in biomedical engineering and one in neuroscience. I waited for the results with stubborn determination that my hard work would be appreciated. To my surprise, my work was actually accepted at both of these national conferences, where most presenters were actually undergraduates or graduate students rather than high schoolers like me. I was elated – my project which had barely made it in a regional science fair is now in national (under)graduate-level conferences.

This taught me a few very important lessons that I hope to relay to future students. First is to think about the bigger picture. Initially, I was hyper fixated on this specific science fair, ignoring all the other opportunities I had to take my project to the next level. When I broke out of this hyper-fixation, I opened myself up to these opportunities and was much more successful. Second is to stay motivated despite what those around you say. Even though the reviewers at the regional science fair believed that my work merited an honorable mention, I stayed determined because I believed that the work I put in deserved more. I stood behind my project rather than questioning if my lack of a higher award was due to my inability or the quality of my work. I truly believe that these two lessons, along with the previous lesson regarding inspiration will allow students like me to stay motivated in the rigorous field of STEM.

Currently, I am an incoming first-year student at the University of California, Los Angeles, pursuing just the subject I nearly gave up on in grade 10, and I still remind myself of the inspirational story of the physician and my memory of science fair to keep myself going. This doesn't mean that demotivation will never strike me again as I go through even more difficult science courses or projects, but what my experience has shown me is how to get out of the spiral of discouragement: look for inspiration in those around you and stay stubbornly determined. And I hope students such as myself have been inspired to do the same.

As for educators, I wish for this account of my experience as a student to inspire you to expand your definition of education and teaching. Confidence and skill in STEM come not only through lessons, readings, and study halls, but is supplemented through inspiration and stories. Tackle demotivation in students by serving as that inspiration – by relating to them and by sharing stories that build confidence. In the end, the best educators are those who keep their

students excited and confident about a subject; not necessarily those with the best organized lectures or hardest tests.

THE INFLUENCE OF A STEM/STEAM EDUCATION BASED HIGH SCHOOL ON STUDENTS OF THE IVOTI INSTITUTE

JASON WILLIAM RICHNER
Ivoti Institute

Abstract:

The aim of this paper is to determine the difference between the STEM/STEAM education High School model and the Traditional Basic General Education High School Model. Another important objective is to explain the benefits of the STEM/STEAM High School format being implemented in the Ivoti Institute, in Rio Grande do Sul, Brazil. I start by giving the definition of STEM/STEAM education, and then discuss the New High School format that is being used in the Ivoti Institute. I explain all the benefits and opportunities that this educational setting brings to the students, and how it has affected my life, personally. STEM/STEAM education is the future of education and will be extremely effective in the development of critical and autonomous individuals.

Keywords: STEM/STEAM Education, Basic General Education, High School Model.

Introduction

The goal of this paper is to emphasize the importance of STEM/STEAM education, and the role it plays in influencing the Traditional Basic General High School model. I will first define and explain the STEM/STEAM education format. I will also present the way it helps students grow in independent learning and to be better prepared for future educational opportunities and careers. Finally, I will share my personal experience in the New High School format, implemented in the Ivoti Institute.

STEM/STEAM Education

According to Marrero, Gunning and Williams (2014), STEM/STEAM education is:

> The term "STEM", an acronym for science, technology, engineering, and mathematics, has come to the forefront of international discourse in education, industry, innovation, and competition. The term is used with students from preschool to postgraduate levels, and to describe careers in the respective fields.

Moreover, according to Xie, Fang and Sbaumann (2015), STEM/STEAM Education is different in each educational level:

> At the foundational K-6 level, STEM education is synonymous with the math and science curriculum that is required for all students, so research on STEM education at the elementary school level focuses on participation and performance in science and math in general. STEM education is defined more specifically as the curriculum becomes increasingly specialized at progressive levels of education. For example, in grades 8–12 multiple tracks through the required math and science curriculum become available to students, as do elective courses in the social sciences (e.g., psychology), computer science, and applied topics in engineering and technology (NGSS 2015).

Some of the benefits of STEM/STEAM education are the development of more independent individuals. The students are more accustomed to technology, making them very capable in the Job Market. STEM/STEAM education brings many benefits to students (Stohlmann,2012), such as:

> Several benefits of STEM education include making students better problem solvers, innovators, inventors, self-reliant, logical thinkers, and technologically literate (Morrison, 2006). Studies have shown that integrating math and science has a positive impact on student attitudes and interest in school (Bragow, Gragow & Smith, 1995), their motivation to learn (Gutherie, Wigfield & VonSecker, 2000), and achievement (Hurley, 2001).

With the implementation of the New High School format, STEM/STEAM education has become a big part of the Ivoti Institute.

New Highschool Format of the Ivoti Institute

In the year of 2022, the Ivoti Institute implemented a New High School format, which has STEM/STEAM education as a main feature. The New High School format enables the development of critical and autonomous individuals, provides them with experiences and processes that ensure the necessary learning, and promotes situations in which students learn to respect one another and live in a society. The New Highschool format is a breakthrough for the students due to the fact that it prepares them for their future career. At present, the students have a choice in which formative course they want to specialize in, helping them choose which area they want to continue in after high school. Each formative course focuses on a different area of knowledge. There are two different kinds of formative courses: one that at the end of High School the student does not receive a Technical Degree, and one that the student does. The two formative courses that give out Technical Degrees are IT and Graphic Design. This differs from the past High School format which only included basic general education classes.

The basic general education consists of the essential classes established by the BNCC (Base Nacional Comum Curricular), which are common to all schools in the country. These essential classes are:

- Languages and their Technologies: Arts, Physical Education, English Language, Portuguese Language, Mathematics.
- Natural Sciences: Biology, Physics, Chemistry.
- Human and Applied Social Sciences: History, Geography, Sociology, Philosophy.

All the classes make up the basic general education offered in Brazil. The basic general education used to be 100% of the High School education, meaning that students did not have formative courses included in their basic general education. The New High School format has basic general education; however, the students are required to take a formative course. The formative courses in the New High School format have been added to the basic general education classes. I noted the difference by talking with my older siblings, who studied at the Ivoti Institute.

My older siblings studied at the Ivoti Institute when the basic general education was 100% of the High School format. They learned general knowledge but did not have the choice to specialize in a specific area. As a result, the school schedule was also different for them. They studied every weekday morning from 7:20 to 11:50 AM, and on Monday afternoons they had class from 1:30 to 4:00 PM. In the New High School format, if a student takes a formative class that is not IT or Graphic Design, he/she has class every weekday from 7:20 AM to 12:50 PM. People who take the IT or Graphic Design course have classes in the afternoon every Monday, Wednesday, and Friday from 1:50 PM to 5:25 PM, and classes in the morning every Tuesday, Wednesday, and Thursday from 7:20 AM to 12:50 PM. The formative classes are very different from one another and specialize in a variety of subjects.

The formative courses constitute the diversified part of the curriculum, where the student can choose what to study according to the proposal offered by the school. Those who begin the 1st year of High School at the Ivoti Institute must choose one or more of the five formative courses: Communication and Humanities, Human Reasoning and Sustainability, Teaching Formation, Technical in IT, and Technical in Graphic Design. The formative courses offer a degree when completed that certifies the students allowing them to work professionally in the area they specialized in. The main idea behind the new format is to prepare students for their future career or help them decide which areas they have most interest in and give them an opportunity to look into those areas. As the years progress, students will get more and more involved in their formative course, having more hours each year.

The formative courses take up a different number of hours each year. In the first year of High School, basic general education takes up 80% of the workload hours, while the formative courses take up 20%. In the second year, basic general education takes up 60% of the workload hours and the formative courses take up 40%. Finally, in the third year of High School, basic general education takes up 40% of the workload hours and the formative courses take up 60%. For the students to keep up with their basic general education, they have to do a lot of work out of school. The New High School format values time and provides students with a large percentage of experiences that contribute to their future.

An important aspect emphasized in the new High School format is the growth of independent learning, which is an aspect that every individual is required to have, if studying in an educational setting. Independence is needed to be able to achieve this kind of learning. As an individual matures, he grows more independent, learning how to do stuff on his own, without the need of supervision. Personally, independence has become a big part of my life, especially in the new format. Doing homework and studying specific knowledge is a decision that I have to make to be able to achieve my goals. The main differences between the new and the old High School format are the number of options available for students to choose from, the importance emphasized in their future, the creative thinking and development of the students, the growth in autonomy and independence of the students, and much more. For the purpose of those conditions to be met, the school has invested in implementing the STEM/STEAM education style, bringing to the school a large percentage of formative courses.

Personal experience with new Highschool format

The implementation of the variety of formative classes brought great change to the Ivoti Institute. Before the new High School, there were limited options. If a student wanted to take a formative course, to graduate with a degree, he/she would have to take extra classes outside of normal school hours. The formative courses were not included in the school program. With the New High School format, students, at the present time, have the choice to take formative courses instead of not having any options to specialize in.

Out of the options I had, at the start of my sophomore year, I chose the Human Sciences and Communication course. I made that choice due to my interest in history. After a period of two weeks, I realized that the other components taught in the class did not interest me, so I looked into the other options. Out of all the other courses, two caught my attention: the IT course and the Graphic Design course. I was trying to decide between the two, so I investigated what each course taught specifically. My number one choice was IT since all my friends were taking it. I ended up choosing the formative course Graphic design as there was no spot for me in IT. At first, I was excited to see what we were going to learn, and it turned out to be a perfectly suitable course for me. At the present time, I realize it is suitable for me due to some aspects from my childhood.

Ever since I was young, I have been interested in creating and building designs out of LEGO. Graphic Design has some areas that are very similar to building things with LEGO. For example, the course teaches developing projects, using creativity to make new and different designs, or even the importance of colors to your design. Another area that intrigued me in Graphic Design was the creation of Logos. I am very interested in the area of architecture as a profession, and when I heard we were going to be creating logos in my technical class, I was very enthusiastic. As I look back at my decision to pursue graphic design, I am very glad the circumstances worked towards this end, and it offered me the experiences I have had in this class.

Nowadays, I compare both the formative course I had chosen first and the one I am in currently and see a large percentage of pros, for example, the use of creativity in my projects. A graphic designer is required to have creativity to make things that have not been made before. To be able to do that, I have learned to implement colors and different techniques to make my work unique. In the course, we train using creativity by doing a plethora of assignments that involve manual work (Drawing, coloring, etc.) and digital work (Designing Logos, making presentations, etc.). These assignments help us prepare to work with an actual client.

While taking this course, even though there are mostly pros, there are a few cons. My family travels a lot back and forth to different countries. The graphic design formative course does not allow students to leave the course during a semester. If a student were to leave for more than a semester, he/she would not receive the certificate at the end of the course. The certificate is essential for the student to be professionally qualified. In my case, my family was going to move out for 6 months and come back after that period of time. My mother and I were not able to travel and had to stay due to the course. Consequently, my father traveled by himself. To take the Graphic Design formative course, the student has to be dedicated, staying with it until the end. In the Graphic Design course, we are taught many things, and are evaluated differently than all the other formative courses.

A big aspect that changed when I switched classes was the evaluation process. A normal evaluation process is done either by a test, in which the student is evaluated by how much he/she knows of the content, or how well he/she did in the assignment. In the Graphic Design formative course, we are evaluated by what we produce in class and our dedication to the projects we receive. Consequently, we end up doing most of our work in class, and not out of it. The teacher asks us to do most of our work in class so they can evaluate our thought process and see us work. Being in the Graphic Design formative course has pushed me to grow in productivity and has helped me create better projects. These experiences have helped me develop my idea of a future, both professionally and personally, and to reflect on how my Graphic Design formative course has impacted my knowledge in the areas of STEM/STEAM.

Graphic Design and STEAM

With the addition of the formative classes, the use of STEM/STEAM Education has become essential in teaching. The teachers have started teaching in a way that stimulates independent thinking, and that helps students learn more from the areas of STEM/STEAM. Personally, I have seen most growth in the areas of Technology, Engineering, Arts, and Mathematics. More specifically, in technology, I have learned to use apps and software in my projects. In Engineering, I have learned to develop and design 3d models and sites. In arts, I have learned multiple drawing techniques, and have learned how to use colors properly. Lastly, in mathematics, I have learned to make all my drawings, logos, and projects very precise. The Graphic Design course has helped me grow in a large percentage of STEM/STEAM areas, in various ways.

Technology

The Graphic Design course I take has really helped me to learn how to use technology in various useful ways. A Graphic Designer has to know how to do all kinds of things. The profession of Graphic Designer in itself requires knowledge in the areas of creating logos. Graphic Designers are known for the purpose of making logos, so I have practiced making logos in the formative course. Graphic Designers also have to know how to make appealing presentations that are aesthetically pleasing and functional. Digital identities are essential in the current world and graphic designers help produce them. Other than that, graphic designers also use digital marketing. Whether it is a post on social media or an ad on the internet, digital marketing is present. With those tasks and requirements in mind, technology is essential in a graphic designer's everyday work.

Up until the present time, in my junior year of high school, I have learned how to use a large percentage of software and apps, such as editing software. I have learned to use Adobe Photoshop that gives me the ability to manipulate any image I want. I can do as much as swap two peoples' heads in a photo to make an entire digital world of my own. Photoshop can be used to make specific adjustments to photo projects, such as adding texture, or manipulating an image to change its color or shape. In my projects, I can use photos that have been taken in real time or

I can use AI generated photos. This causes my possibilities to be infinite in things I can create. I have learned how to use Adobe Illustrator, which is essential in the creation of logos. Illustrator gives me the possibility to make precise lines and shapes of all kinds. It also helps me make physical items (such as a shoe) into a digital item. Recently, I made a digital shoe based on a real shoe. Another software/app I have learned to use is Canva. In Canva, one can create almost anything they want. With the vast number of images, items, shapes, stickers, and colors I can design presentations, posters, flyers, logos, banners, cards, invitations, menus, eBooks, booklets, infographics, resumes, presentations, t-shirts, and much more. Canva is the app that I use the most, due to its functionality. I can access my projects on a computer, or even on my phone, to continue working on it. I learned how to use Cap Cut to edit videos and photos. It has a lot of features that make photo and video editing a piece of cake. I can add all kinds of effects to my photos and apply different kinds of transitions in my videos. Finally, Tinkercad is a website where I can create 3d designs. The site has a large variety of shapes and objects (such as gears) that can be manipulated to create a 3d visualization of a project. I can select from a variety of models, of things such as products and objects, to provide a visual result for a client to see. All of these features contribute to my projects and make my work much easier and enjoyable to do. Without technology, a Graphic Designers job would not be possible.

Engineering

Another area my Graphic design class has helped me grow in is the area of Engineering. During the first year of the formative course, I learned basic coding, such as Python and HTML, and I designed sites using the codes. The project focused on designing a site that was attractive aesthetically, could grab the attention of its users, and focused on how to bring more and more users into our site. I saw that technology, in general, can be more attractive to users if it is simple to use. People are more attracted to a site that does not take a lot of work to handle, and will get them to their destination in a short period of time. Another aspect that attracts people to a site is its reputation. If a site is well known for the purpose of giving the clients what they ask for, it is more popular. A large percentage of other aspects are involved in making a website that attracts users. To make my website I used my basic coding knowledge and Google Sites. Engineering can be useful in a large percentage of areas.

Another area I have applied engineering to is model development and designing. To develop a model and design it, I have used tools along the lines of Tinkercad and photoshop. This software has brought infinite possibilities to the things I can create, helped me engineer 3d models and make productions with photo engineering, and contributed to the growth of my knowledge in the area of Engineering. In the future, I plan to pursue a career in architecture. I believe the knowledge I have gained in Engineering will contribute to my future career. Tinkercad can be used to create 3d models of houses, rooms, and all kinds of things. After drawing a blueprint of a house manually, I can make a 3d model of it on Tinkercad. I can also use Photoshop to make AI generated photos, or concepts of a house for the purpose of a client.

Engineering is an important part of my role as a graphic designer, but an even more relevant part is Arts.

Arts

The third area that the Graphic Design formative course I participate in has helped me grow in is Arts. Arts is the fundamental characteristic of Graphic Design. The Psychology of colors and typography are essential in the process of creating graphical productions. The Psychology of colors is the message and the feeling each color induces in a human being. Color can induce feelings, for example, sadness, happiness, and fear. They can also change the way you think and act. Colors play a huge part in the world, and so in our Graphic Design course we learn to use them properly. Typography is also a fundamental aspect of a project. Different fonts send different messages and help build a different idea. For example, if I want to make a title for a movie about aliens, I am surely going to use a futuristic looking font. Both the typography and the psychology of colors contribute to the aesthetic part of a project, which is one of the most relevant parts. I have learned how to use drawing and painting in class. I design a plethora of models by hand and that requires basic skills in the area of drawing. More specifically, I have drawn houses, scenes. objects, and people using techniques such as perspective, shading, stippling, pointillism, contour drawing, etc. I learned all of these techniques in class and have used them to create drawings to this day.

The area of arts also involves marketing. Each company has a color that represents it. For example, some of the most famous companies can be identified by the color they use in their logo. That shows the influence color has on people, and how it can be used in marketing. The influence of colors and typography on a client is fundamental in marketing, and each color makes the client feel in a specific way. The color blue is more attractive than the color brown, so if I make an advertisement with a certain color, it may affect the client's choice. The area of arts is also very interconnected with the area of mathematics.

Mathematics

The fourth and final area that the Graphic Design formative course has helped me grow in, is mathematics. One of the main characteristics of a good project is its preciseness and cleanliness. When a drawing or a logo is made with perfectly round edges and perfect symmetry, it is much more appealing than a poorly made one. Math is extremely important in the execution of a project.

Math is used mostly in drawings. To draw a specific perspective and execute it, I have to use Math. Angles are involved in perspective and are fundamental in drawing. A large percentage of times I have to use a ruler to be able to make a drawing that is symmetric and correct. Geometry as well is used in drawings to form shapes and lines. In the Graphic Design formative course, I have learned how to make drawings using math, and have learned in regard to how math is used in a digital setting. The Golden ratio is used in a large percentage of the

most famous logos. The Golden Ratio appears in some patterns in nature and is used to analyze the proportions of natural objects and artificial systems such as financial markets. In general, math is used in the construction of logos, drawings, and all other projects I work on in the Graphic Design formative course.

Final Considerations

As I have put forth in this paper, the transition the Ivoti Institute has made from the Traditional Basic General Education model into the New High School format, having STEM/STEAM Education as a highlight has greatly benefited my growth and learning process. I have experienced growth in the areas of Technology, Engineering, Arts, and Mathematics, and have learned to be a more independent learner. In general, the STEM/STEAM Education format is superior to the Traditional format and will be more effective in the development of critical and autonomous individuals.

References

Bragow, D., Gragow, K.A., & Smith, E. (1995). Back to the future: Toward curriculum integration. *Middle School Journal*, *27*, 39–46.

Gutherie, J. T., Wigfield, A., & VonSecker, C. (2000). Effects of integrated instruction on motivation and strategy use in reading. *Journal of Educational Psychology, 92,* 331–341, doi: 10.1037/0022-0663.92.2.331.

Hurley, M. (2001). Reviewing integrated science and mathematics: The search for evidence and definitions from new perspectives. School Figure 1. The s.t.e.m. model of considerations for teaching integrated STEM education. *Science and Mathematics, 101*, 259–268, doi: 10.1111/j.1949-8594. 2001.tb18028.x.

Marrero, M. E., Gunning, A. M. & Williams, T. G, (2014). *Considerations for Teaching Integrated STEM Education.* Twin Cities: University of Minnesota.

Morrison, J. (2006). TIES STEM education monograph series, Attributes of STEM education. *Baltimore*, MD: TIES.

Next Generation Science Standards. (2015). *THE THREE DIMENSIONS OF SCIENCE LEARNING:* USA. http://www.nextgenscience.org/

Stohlmann, M., (2012). *What is STEM Education?* New York: Mercy College.

Xie, Y., Fang, M., and Sbaumann, K., (2015). *STEM Education.* Department of Sociology, University of Michigan, Ann Arbor, Michigan 48106, University of California, Davis, California 95616.

EDUCATORS' REFLECTIONS

DISRUPTING STEM EDUCATION BY BRAIDING INDIGENOUS WAYS OF KNOWING AND ENVIRONMENTAL EDUCATION

STÉPHANIE DODIER.
Simon Fraser University

Abstract

Learning is inherently connected. It is time to disrupt traditional STEM education by meaningfully embracing multiple perspectives such as Indigenous and environmental education learning principles. Through my story as a white non-indigenous science teacher, we explore the importance of acknowledging one's feelings, the power of storytelling, my journey educating myself and embracing multiple perspectives inside my teaching practice. Because Aboriginal Ways of Being state that the "the deepest learning takes place in lived experience" (BCTF, 2017), I share my process and reflections on designing and implementing a specific unit about clam gardens in a secondary science classroom.

Keywords: Indigenous pedagogy, place-based education, storytelling, science education, Traditional Ecological Knowledge, experiential learning.

Introduction

When I think about learning, I see a giant spider web of connections where one concept or skill is connected to the next, and so forth. Learning goes beyond isolated silos – ie. physics, biology, chemistry, social studies – and expands outside of the classroom doors to the complexity of life. Learning needs to be connected to real-life to gain its meaningfulness. Learning is inherently connected. That concept is shared with Indigenous and environmental education learning principles. "Learning is holistic, reflexive, reflective, experiential, and relational (focused on connectedness, on reciprocal relationships, and a sense of place)" (FNESC, n.d.). The previous statement is one of the nine First Peoples Learning Principles elaborated by the First Nations Steering Committee "to contribute to Reconciliation for all by building a greater understanding of the skills, knowledge, and perspectives of First Peoples for all students" (FNESC, 2016, p. 4).

When looking at environmental education definitions, there is not one specific definition that stands out but there are clear common themes. Based on the analysis of various definitions (BC Ministry of Education, 2010; NAAEE, 2021; UNESCO-UNEP, 1976, 1977), environmental education is taught with a **holistic approach** (connected, interdisciplinary, and integrated) that puts the **learner at the center of their learning** on **real-world contexts** to increase **awareness** (responsibility, action, and stewardship). When looking at environmental learning principles, the BC Ministry of Education (2010) proposes the acronym C.A.R.E to promote looking at environmental issues through multiple perspectives but also to demonstrate various forms of environmental knowledge.

Figure 1. *Use "CARE" to deepen environmental learning.*

(BC Ministry of Education, 2010)

> "Through a consideration of these principles for environmental education, you, as teachers, will come to understand that experiential programs can examine the complexity of natural systems. Human interaction with these systems and the effect on these systems is also examined. You will also learn that holistic forms of environmental education can help your students to develop a sense of respect and appreciation for the natural world. An aesthetic appreciation, along with a scientific understanding of nature, encourages students to learn and act to protect and sustain the environment. This, in turn, can contribute to self-awareness and personal fulfilment." (BC Ministry of Education, 2010, p. 11)

These tenets of environmental education will not be in all environmental education resources – they are guiding principles.

My Story

As a secondary science teacher, I make a conscious effort to braid Indigenous ways of knowing and environmental education into my teaching practice. I would like to share my humble journey toward reconciliation as a settler on these traditional lands. In that spirit of reconciliation and appreciation for the land, I would like to acknowledge that I am privileged to write these lines, work, and play on the unceded and traditional territories of the xʷməθkʷəy̓əm (Musqueam), Sḵwx̱wú7mesh (Squamish), and səlilwətaɬ (Tsleil-Waututh) peoples.

I would like to share a unit about clam gardens that I have co-designed with the Indigenous Support Team of my school district and validated Indigenous resources (FNESC, 2016). This unit targets grade nine students in a francophone school in a minority context in British Columbia on the Pacific Northwest. The students came from different socio-economic backgrounds and each class portrays a wide array of learning disabilities. It is to be noted that the framework presented can be used in a variety of settings, grades, and subjects. I want to acknowledge that my clam garden unit is by no means "perfect" in itself. On the contrary, it depicts well some of the challenges and barriers when one is wanting to integrate Indigenous ways of knowing and environmental education principles in their practice.

By presenting a concrete example of what it means to integrate Indigenous perspectives inside a science curriculum, I hope to inspire settlers to take their first steps towards representing Indigenous worldviews no matter where they are in their reconciliation journey. During a professional development opportunity, it was shared with me by an Elder that: "We [Indigenous peoples] would rather that you try than you do nothing." I also connect with this saying by Maya Angelou: "Do the best you can until you know better. Then when you know better, do better"**.** Furthermore, it is important to use validated resources to ensure that the inclusion of First Peoples' perspectives is done respectfully and without appropriating First Peoples' knowledge. These sayings have guided my journey and I share them with future student teachers in my role as a sessional instructor in the Teacher Education Program at Simon Fraser University.

Braiding Indigenous Ways of Knowing

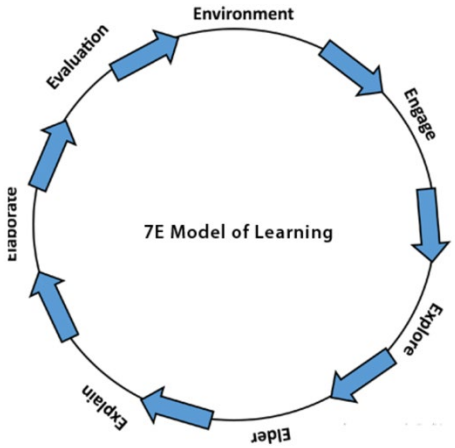
There is a historical tension between STEM education and Indigenous Ways of Knowing. Some portray the two as oppositional when, in reality, there are multiple ways of learning. As teachers, the challenge resides in establishing bridges between the latter. Furthermore, I believe this tension is partly rooted in the uneasiness – or even shame – settlers of this land experience for the generational trauma we have caused to First Nations across Turtle Island. The number one challenge I hear from future science teachers on integrating Indigenous knowledge in STEM education usually goes along the lines of "*I am afraid to make a mistake*" or "*I don't want to make it worse*". Shame is paralyzing. We must step outside of its realm to recognize, educate ourselves on the past and current situation to be able to enact the Calls to Action (First Nations University of Canada, 2023).

As a science teacher and settler on this land, I was deeply feeling this tension. Fortunately, I was able to break the cycle of inaction. I initially resonated with the Two-Eyed Seeing approach – a concept presented by Mi'kmaq Elder Albert Marshall (Hatcher, Bartlett, Marshall, & Marshall, 2009). I learned that STEM education and Indigenous knowledge can co-exist and even thrive together. *Toqwa'tu'kl Kjijitaqnn* means *"*Integrative Science" in the Mi'kmaq language and it brings together "Indigenous and Western knowledge using the guiding principles of 'Two- Eyed Seeing' that is, to see from one eye with the strengths of Indigenous ways of knowing, and from the other eye with the strengths of Western ways of knowing, and to use both of these eyes together" (Hatcher et al., 2009, p.3). When we look at this approach with an inclusive lens, "the approach is beneficial to all students because it adds an engaging cultural dimension to science studies, provides context for learning about other nations, and demonstrates that all knowledge has a cultural context" (Hatcher et al., 2009, p.3).

With this approach in my toolbox, I continued navigating the recognition and integration of Indigenous ways of knowing. I then learned about First Peoples pedagogy. FNESC (2016, p.5) argues that "while each First Nation has its own unique identity, values and practices, there are commonly held understandings of how we interact and learn about the world." FNESC states that First Peoples pedagogy is based on the following principles: it is "**learner centred**, […] **inquiry based**, […] based on **experiential learning**, emphasize an **awareness of self and others** in equal measure, recognize **the value of group processes** [and] **support a variety of learning styles**" (FNESC, 2016, p. 5, emphasis added).

Based on those tenets, FNESC presents an adaptation of the commonly known 5E model of learning (Bybee et al., 2006). The 5E model is widely used to develop experiential learning resources. It has been proven to promote "collaborative, active learning in which students work together to solve problems and investigate new concepts by asking questions, observing, analyzing, and drawing conclusions" (Lesley University, n.d.). The 7E model of learning is similar to the 5E model but with the addition of 2E which stand for Environment and Elder.

Figure 2. 7E Model of Learning (adapted and used with permission from FNESC)



7E Model
Environment
Situate the lessons in the local land and environment. This builds an appreciation for the concept that everything is connected to everything else and taps into a sense of Place.
Engage
Capture student attention and curiosity. Raise scientifically relevant questions. Connect what students know with a new question or idea. Ask a question, show something interesting, pose a problem.
Explore
Experiential. Students observe, record, connect ideas, ask questions, usually in groups. Teachers are coaches and facilitators.
Elder
Elders and other knowledgeable community members represent the Traditional Ecological Knowledge held by the community.
Explain
Describe observations and come up with explanations. Develop vocabulary, apply and interpret evidence. Students reflect on their processes, thinking and conclusions. Teachers guide students with questions and suggest additional resources.

Elaborate
Use information to extend learning to **new situations.** Make connections to their personal lives and to society.
Evaluation
Students **demonstrate their understanding** of concepts and skills learned. Teachers ask open-ended questions and encourage students to self-assess their learning.

(FNESC, 2016)

Note. This model provides a framework to begin the planning process and it was instrumental for the co-design of my unit on clam gardens. I have used this model to present a summary of this unit.

Clam garden unit

Environment

Because Indigenous ways of knowing are inherently place-based, it makes sense to start with the environment. In an ideal world, we would have organized a field trip to a local intertidal zone to get a sense of intertidal critters and connect with the environment on a multi-sensory level – smell of fresh ocean air, temperature of water on our feet/hands, sounds of marine creatures, beauty of nature, ... Place-based learning is "a process that centers respect, reciprocity, reverence, humility, and responsibility as values" (Canadian Commission for UNESCO, 2021). These values are essential to engage in meaningful environmental education opportunities and hold the premise for tackling complex global environmental challenges. However, I encountered an issue hindering this venture due to logistical issues and a lack of funding for transportation. In hindsight, I would have planned and applied for funding through numerous grant opportunities in the province. Because the reality is often different from the theory, I did what all educators do daily – use a plan B! Instead, students experienced a multi-sensory experience of clams – the texture, the smell, the appearance, the taste – by cooking a clam chowder in the school's kitchen. For most students, it was their first time tasting clams. We were also able to see what types of clams were sold in local supermarkets compared to the ones found on local beaches.

Engage

Using an experiential approach to begin the unit has tremendous power to engage students. The latter were engaged in the clam chowder cooking activity because the cooking connects to their everyday life, it is hands-on, and it supports a variety of learning styles allowing for all students to engage.

Explore

At this point, students were curious to learn more about clams. I wanted them to explore Indigenous Resources to find out more about the topic. One of those resources was the Húy̓at website. With a simple click, you enter the immersive world of Húy̓at; our voices, our land. You are welcomed on this website with Indigenous voices speaking in the background about the importance of this land whilst seeing bird-eye videos of their land. You *enter* and find yourself on the main page with options written in Hiłzaqv (Heiltsuk) language with an English translation when you hover your mouse on top.

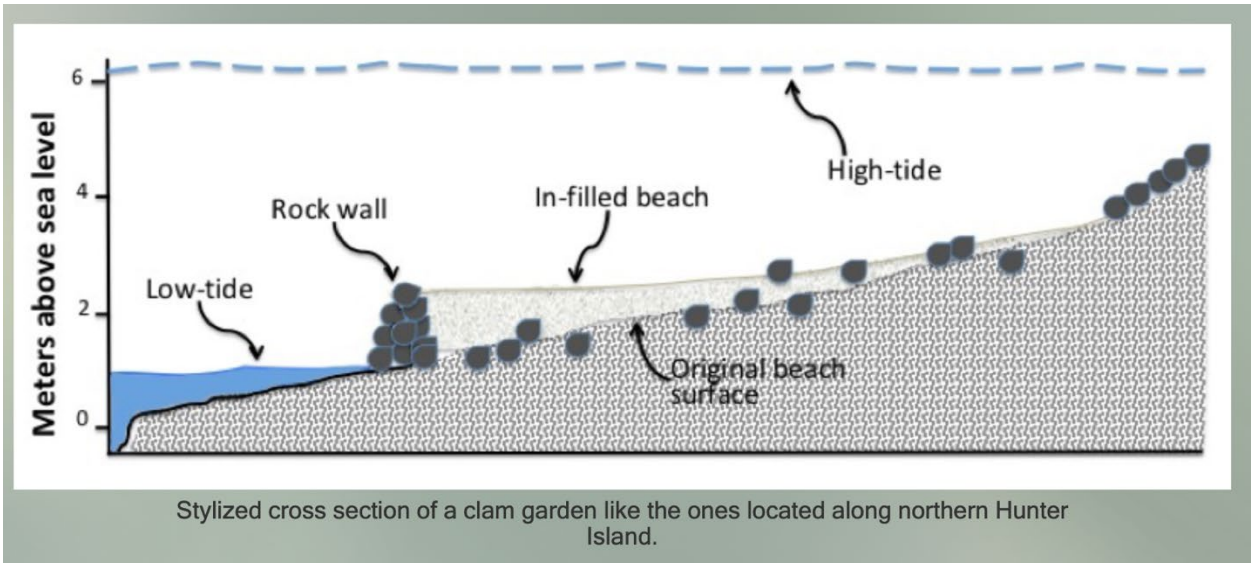
> HÚY̓AT is one of an immense network of culturally important places in Heiltsuk territory. It is the land where Ċuḿqlaqs gave birth to her wolf children, and where we have lived for millennia, making our imprint on the land. Húy̓at collectively refers to several socially and geographically connected bays on northern Hunter Island, located in what is known today as the Central Coast of British Columbia. Húy̓at is just down the channel from the present-day village of Bella Bella where many of our people now live (Húy̓at, n.d.).

This website was born from a collaboration between the Heiltsuk Nation, researchers and project partners from Simon Fraser University, the University of Victoria, and Greencoast Media. The knowledge used to construct this website comes from diverse sources –- from Heiltsuk memories, language, and oral traditions but also "community-initiated research, ethnographic sources, and archival documents assembled in the Heiltsuk Cultural Education Center (HCEC), as well as about 30 interviews conducted specifically for this project" (Húyat, n.d.). Not only is it possible for viewers to view a video presenting traditional AND scientific knowledge thriving together, but this resource is also a concrete example of the Two-Eyed Seeing approach. It is a compelling testament to the power of stories and other ways of knowing. Simply telling students that stories and oral traditions are a form of knowledge does not resonate as much as **experiencing** a concrete powerful example such as Húy̓at. This aspect of the unit is significant because it allows for experiential learning of an abstract concept but also it connects to the sense of place by connecting with local First Nations and the stories about their lands. Because the site provides beautiful images and videos of remote places, it also allows for an alternative entry point to foster an aesthetic appreciation of the environment/land. Because of its close ties to outdoor education, we often assume that environmental education must take place outdoors. Environmental education *can* take place outside, but it is *not* a requirement.

Through their exploration of the website, students were able to see images of clam gardens and understand what they are. For those of you who haven't looked it up already, you might be intrigued as to what clam gardens are. Students can find the following information through their exploration of Húy̓at. Clam gardens are traditional and sustainable practices designed by Coastal First Nations for a sustainable and abundant harvest of clams.

> Clam gardens are rock-walled terraces that our ancestors built at the lowest low tide to increase the particular tidal zone in which clams thrive. By creating a terrace at a particular place above sea level, sediment could accumulate behind the rock walls and then clams could flourish. […] Archaeologists have not been able to date the clam gardens in our territory, but based on work elsewhere on the coast, they could be several thousands of years old. Interestingly, most of the clam gardens in Húy̓at are not located in central Húy̓at – where the majority of people lived. People in central Húy̓at almost certainly held the rights to harvest clams from these other bays (Húy̓at, n.d.).

Figure 3. *Stylized cross-section of a clam garden like the ones located along northern Hunter Island*



(Húy̓at, n.d.)

Note. Figure 2 allows for a better understanding of what a glam garden would look like. This information is shared on the website through text, figures, and a video which allows for differentiation.

Elder

When we reached out to Elders in our community, they weren't available to visit. It was an unfortunate situation because they represent the Traditional Ecological Knowledge (TEK) held within the community. But I like to think that when one door closes, another one opens. "Teachers are encouraged to develop local units that speak to the local sense of place and non-appropriated knowledge of local First Nations, in collaboration with knowledgeable community members" (FNESC, 2016, p.16). The discovery of Húy̓at allowed me to connect with other knowledge keepers. It also triggered an encounter with a passionate individual who helped me expand my understanding of clam gardens in general but most importantly she shared her relationship with Indigenous knowledge. Dr. Dana Lepofsky is a local SFU professor and archeologist who has worked on the Húy̓at project and other various research projects in collaboration with Coastal Indigenous Peoples. She has a profound appreciation for Traditional Ecological Knowledge and for the Elders who shared their stories with her. As a scientist, she understands the value behind the Two-Eyed Seeing approach and she was able to present her *discoveries* on clam gardens (for the Western World) through articles based on data gathered from diverse sources. She explains:

> I incorporate diverse technical and methodological approaches in my research, including interviews with knowledge holders, ethnohistoric research, geomorphology, archaeological survey and excavation, paleoethnobotany, and paleoecology. My recognition of the value of different disciplines and kinds of knowledge has led me to believe strongly in multi-disciplinary and collaborative research (Lepofsky, n.d.).

She was able to talk directly to my students about her role as a scientist in the field partnering with local First Nations. She talked about her first-hand experience with TEK and how it has helped her further her understanding of the sustainable and traditional practices of clam gardens. To me, that is learning that expands beyond the classroom doors. Although it is portrayed as such, science is not objective, and it does not come from a textbook or a powerpoint – it is relational. As a scientist, you need to be ready to learn from your peers and other ways of knowing. Teaching explicitly the nature of science is unfortunately underrepresented in school science.

Explain

Above I explained how students began forming their understanding about clam gardens through a confirmation inquiry on the Húy̓at website. Additional resources for a more thorough understanding came from the resources in Unit 1 about Traditional Ecological Knowledge (FNESC, 2016) where clam gardens are cited as a TEK example. Learning about the Traditional Ecological Knowledge of Indigenous peoples is a prescribed concept within the science curriculum in British Columbia. Beyond that, it can significantly enhance students' appreciation

and respect for TEK. This exposure to TEK sparked a conversation about other areas where TEK could come into our lives.

Furthermore, multiple concepts and skills were developed and connected back to the concept of sustainability behind clam gardens. Some of the concepts included matter cycles, sustainability, invasive and indigenous species, bioaccumulation, and biomagnification. Using a concrete example helped support the understanding of abstract concepts – ie. bioaccumulation. When looking at the acronym C.A.R.E for environmental education , clam gardens touched on numerous aspects – the **C**omplexity of systems involved in clam gardens and the interconnectedness nature of TEK, the **A**esthetic design of intertidal terraces and global appreciation for the environment, our **R**esponsibility as stewards of the land to protect and promote sustainable practices, and finally hope that the study of the environment can help students develop an environmental **E**thic. "[…] responsible action requires an examination of values. Environmental education provides an opportunity for students to question cultural assumptions that lead to social conflict and environmental crises" (BC Ministry of Education, 2010). It's time to start valuing TEK and Indigenous ways of knowing as important knowledge.

Elaborate

Students were able to extend their learning in multiple ways. First, their interaction with a scientist was a meaningful opportunity to learn about the realities of field research. Seeing concrete examples of career options is important for students to start forming their ideas about what happens outside of school science. In addition, seeing that a distinguished scientist uses TEK in her practice breaks down further the historical tension between Western and Indigenous science.

After learning about a sustainable practice such as clam gardens, students were asked to extend their understanding of sustainability to other areas of their lives. They had to develop a solution for a sustainability issue and present their pitch to the audience. This project was conducive to students reflecting on possible sustainable solutions they could implement in their lives or their community. Students were asked to develop a concrete plan that allowed them – or someone – to put it into action if they were inclined to do so. Their pitch to the classroom had to include enough details for us to see the feasibility of this project coming to fruition. Providing real-world examples helps motivate students because it allows them to make essential connections with their learning. Furthermore, developing solutions fosters students' agency and allows them to feel empowered. When presenting their solution, they were asked to connect with TEK principles and elaborate on which was applicable. **"**As educators, we need to facilitate students' understandings of what constitutes responsible action toward the environment and help students to act responsibly in their personal lives" (BC Ministry of Education, 2010). This project was a good opportunity for students to apply their learning about sustainable practices to new situations.

Evaluation

Students were evaluated on multiple criteria that included targeted content, curricular competencies, and core competencies. Their comprehension of concepts was evaluated on how they could apply their conceptual understanding to known and new situations through a variety of questions. Some of the concepts and skills evaluated included being able to explain how the clam gardens were a good example of sustainability, explain how clams were affected by bioaccumulation, explain how TEK is valuable to research and our understanding of the interconnection of the world surrounding us. For some of the questions, students were able to exercise choice on how to demonstrate their understanding through a written explanation, annotated drawings, or a little presentation to younger students.

Their analyzing skills were evaluated when they made sense of Dr. Lepofsky's research data on clam gardens. Other competencies – design skills, communication skills, and creativity – were also evaluated through a performance task which was their pitch done either in-person or via pre-recorded video.

Circling back to the Environment

For the students' pitch, I invited the administration to attend. When you offer students an audience to present their work, the result is often elevated. In addition, the principal was highly motivated to bring to fruition the solutions students were proposing for the school. An example of that was a rain barrel installed at school to water the school's garden. This iterative model is conducive to learning expanding beyond the classroom doors.

Storytelling

Let's look at the way storytelling was embedded not only inside this unit but also in this article. "Learning is embedded in memory, history, and story" (FNESC, n.d.). Stories are everywhere – oral stories of Coastal First Nations on the Húy̓at website, Dr. Lepofsky's research journey embracing Indigenous knowledge, and students' stories about the solutions they found to real-world problems, my own reconciliation journey, ... As stated by Aboriginal ways of knowing and being, "important teachings emerge through stories" (BCTF, 2017). While Indigenous Peoples have understood the power of storytelling for quite some time, recent neuroscience research corroborates that "our brains are socially and emotionally hard-wired to absorb stories" (Oliver, 2023, p. 1). When we listen to stories involving some facts, our understanding process involves an emotional component which activates the amygdala in concert with the hippocampus – two independent memory systems (Oliver, 2023). The level of emotional arousal during encoding correlates highly with subsequent recall (McGaugh, 2004). "That is why we can more easily recall an emotive story than a dry statement of several facts" (Oliver, 2023). Morris et al. (2019) argue that "narratives structured as stories facilitate experiential processing, heightening affective engagement and emotional arousal, which serve as an impetus for action-taking" (p. 1). Not only do students remember better stories than factual

knowledge, but they also are more likely to act consequently – i.e.. engage in pro-environmental behavior (Morris et al., 2019).

Climate change education is an important component of both environmental education and Indigenous learning principles. "Learning involves recognizing the consequences of one's actions" (FNESC, n.d.). However, throughout Canada, climate change education is mostly an afterthought. Only a third of educators teach about climate change and for those who do, it represents between one to ten hours of instruction per year or semester (Field, Stevens, Spiropolous, & Acton, 2021). In addition, climate change education is often limited to simplified technical scientific concepts (Field et al., 2021). I would argue that this strictly conceptual approach – far from emotions – is in dissonance with the eco-anxiety felt by an increasing number of students worldwide (Hickman et al., 2021). According to Field et al. (2021), 46% of students aged 12-18 years old are aware that human-caused climate change is happening, but they do not believe they can do anything about it. Hopelessness leads to inaction and anxiety. Communicating effectively climate change information to diverse – sometimes non-scientific – audiences require us to consider alternative approaches to analytical narratives. Storytelling can act as a powerful tool. Science is done by scientists all over the world. When we talk about science in general, these people's stories of exploring the unknown are important and maybe even more powerful than simple scientific facts. Stories don't necessarily need to be told. Going back to climate change education, stories about the solutions and actions needed for our future on this planet can also be **co-created** with our learners, our community, Indigenous Peoples, and ourselves. Climate change isn't a subject to be taught – it's a crisis to explore together.

Conclusion

Braiding new perspectives inside STEM education can feel like a colossal task but it does not have to be. There are multiple entry points for all to begin somewhere. I have shared with you my story of disrupting STEM education to model vulnerability. "Learning is a journey that takes courage, patience and humility" (BCTF, 2017). My journey started by acknowledging my feelings on different perspectives, educating myself and embracing different ways of learning, and establishing meaningful connections within the community. The story does not end – it continues with me sharing, growing, and acknowledging that it is not an easy task, but it is worth it. All educators must start and pursue their reconciliation journey by enacting the Calls to Action (First Nations University of Canada, 2023). It is our honour and duty to do so. Besides, if we go back to our spider web of learning. "Learning recognizes the role of indigenous knowledge" (FNESC, n.d.). Indigenous ways of knowing and environmental education are part of the learning web. We just need to make the connections.

Bibliography

BC Ministry of Education. (2010). Environmental learning and experience: An Interdisciplinary guide and video clips for teacher (2007). Retrieved from http://www.bced.gov.bc.ca/environment_ed/.

BCTF. (2017). Aboriginal ways of knowing, (July), 2017.

Bybee, R. W., Taylor, J. a, Gardner, A, Scotter, P. V, Powell, J. C., Westbrook, A, & Landes, N. (2006). The BSCS 5E instructional model: Origins, effectiveness, and applications. *Bscs*, 1–19. Retrieved from papers://dee23da0-e34b-4588-b624-f878b46d7b3d/Paper/p424.

Canadian Commission for UNESCO. (2021). Land as teacher: Understanding Indigenous land-based education. Retrieved from https://en.ccunesco.ca/idealab/indigenous-land-based-education.

Field, E., Stevens, J., Spiropolous, G., & Acton, K. (2021). Canada, climate change and education: Opportunities for public and formal education A project of With support from Focus on British Columbia Regional Report.

First Nations University of Canada. (2023). What are the Truth & Reconciliation Commission's 94 Calls to Action & How Are We Working Toward Achieving Them Today? Retrieved July 31, 2023, from https://www.reconciliationeducation.ca/what-are-truth-and-reconciliation-commission-94-calls-to-action.

FNESC. (n.d.). *First Peoples Principles of Learning*. Vancouver, BC. Retrieved from http://www.fnesc.ca/wp/wp-content/uploads/2015/09/PUB-LFP-POSTER-Principles-of-Learning-First-Peoples-poster-11x17.pdf.

FNESC. (2016). Science FIRST PEOPLES Teacher Resource Guide.

Hatcher, A., Bartlett, C., Marshall, M., & Marshall, A. (2009). Two-Eyed Seeing: A cross-cultural science journey. *Green Teacher*, *17*(Fall), 3–6.

Hickman, C., Marks, E., Pihkala, P., Clayton, S., Lewandowski, R. E., Mayall, E. E., … van Susteren, L. (2021). Climate anxiety in children and young people and their beliefs about government responses to climate change: a global survey. *The Lancet Planetary Health*, *5*(12), e863–e873. https://doi.org/10.1016/S2542-5196(21)00278-3

Húyat. (n.d.). Húyat. Retrieved from http://hauyat.ca/.

Lepofsky, D. (n.d.). SFU's biography of Dana Lepofsky. Retrieved July 31, 2023, from http://www.sfu.ca/archaeology/about/people/faculty/dlepofsky.html.

Lesley University. (n.d.). Empowering students: The 5E model explained. Retrieved July 31, 2023, from https://lesley.edu/article/empowering-students-the-5e-model-explained#:~:text=The 5E Model%2C developed in,%2C analyzing%2C and drawing conclusions.

McGaugh, J. L. (2004). The amygdala modulates the consolidation of memories of emotionally arousing experiences. *Annual Review of Neuroscience*, *27*, 1–28. https://doi.org/10.1146/annurev.neuro.27.070203.144157

Morris, B. S., Chrysochou, P., Christensen, J. D., Orquin, J. L., Barraza, J., Zak, P. J., & Mitkidis, P. (2019). Stories vs. facts: triggering emotion and action-taking on climate change. *Climatic Change*, *154*(1–2), 19–36. https://doi.org/10.1007/s10584-019-02425-6

NAAEE. (2021). *Environmental education materials: Guidelines for excellence*. Washington, DC. Retrieved from http://resources.spaces3.com/3725a5c0-f0ab-4039-9bd2-c5dbd9bcb34f.pdf.

Oliver, C. A. (2023). The social brain and the neuroscience of storytelling. *Teaching Science Students to Communicate: A Practical Guide*, 31–38. https://doi.org/10.1007/978-3-030-91628-2_4

UNESCO-UNEP. (1976). The Belgrade charter on environmental education. *Prospects*, *6*(1), 135–136. https://doi.org/10.1007/BF02220144

UNESCO-UNEP. (1977). Tbilisi declaration. *Environmental Policy and Law*, *3*(3–4), 196. https://doi.org/10.1016/S0378-777X(77)80134

SCHOOL LEADERSHIP DEVELOPMENT FOR SUSTAINABILITY IN THE POST-DIGITAL ERA

AWODIJI, OMOTAYO ADEWALE
ULEANYA, CHINAZA
NAICKER, SURAIYA RATHANKOOMAR
University of Johannesburg

Abstract

The role of school leaders must be balanced in attaining educational sustainability in the changing world. Millions of school students worldwide were affected by the COVID-19 shutdown, which accelerated the need for rapid digitalisation. The United Nations Sustainable Development Goals (SDGs) are embedded in 21st-century education. The ability to reorient students to the SDGs is key to achieving sustainable education in the post-digital era. This study examines school leadership development in a post-digital era from the sustainability perspective. To ensure sustainable education, school leaders must have relevant skills and competencies to lead schools in the post-digital age. In striving for a sustainable era, a school leader needs skills and knowledge to be an inspiring role model and motivator. School leaders must reorient students, teachers, and all relevant stakeholders according to SDG goals to achieve sustainable education. Hence, continuous school leadership development is essential to accelerating digital transformation using factors such as leadership style, strategic planning, and knowledge management.

Keywords: School Leaders, Leadership Development, Educational Sustainability, Post-Digital, Digitalisation, SDGs

Introduction

The world's sustainability challenge is borne out of the many challenges facing humanity's ability to sustain technology and the earth's ecosystem (Rosen, 2018). Sustainability is primarily recognised in the concept given in the Brundtland Report as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Michelsen & Fischer, 2017, p. 136). Sources of sustainability challenges include water, energy, minerals, food, waste management, pollution, and climate change. As a result, there has been a systemic drive to ensure sustainability on the planet (Mensah, 2019). The drive towards sustainable development in the modern political system began in the 1950s when the inhabitants of the northern and western parts of the world began discussing the challenges of a civilisation pattern guided by technological and industrial advancements, which may sometimes be harmful to the environment (Barbosa et al., 2014). The Sustainable Development Goals (SDGs) were formally established through the commitment of nations' governments in 2012 during the United Nations (UN) Rio +20 summit in Brazil (Chin et al., 2019). The summit aimed to "reverse the destruction of our natural and social habitats and to achieve a more balanced and equitable pathway towards the well-being of all" (UN, 2019, p. 56).

The agenda of sustainable development set by the UN recognised the role of education and the necessary steps to ensure sustainability in education. The agenda thus captured the necessity of education as “critical for promoting sustainable development and improving the capacity of the people to address environment and development issues” (Burmeister & Eilks, 2013; UNCED, 1993). Thse place of education in achieving sustainability is emphasised by the understanding that education is instrumental in enabling individuals to become responsibly engaged citizens making positive contributions to develop the global society sustainably (Michelsen & Fischer, 2017). In a similar vein, sustainable development and the pursuit of sustainability are integrated into the characteristics of the general mandate of education (Rauch & Steiner, 2006). Therefore, sustainability gives credence to education's purpose, which is to contribute to the development of a society reflectively and responsibly for a sustainable future.

The term “Education for Sustainable Development” (ESD) was created as a part of Agenda 21 (UNCED, 1993), which recognises the role of education in promoting sustainable development and improving people’s capacity to tackle environmental and developmental challenges. In 2015, the UN implemented the 2030 Agenda and the concerted 17 Sustainable Development Goals (SDGs), which lay out the specific intersection of education and the drive towards sustainable development. The established SDG4, which stands for quality education, reiterates ESD and, in its seventh goal (4.7), states that:

> By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and

> appreciation of cultural diversity and culture's contribution to sustainable development (Ferrer-est & Chalmeta, 2021, p 2).

However, the new normal in the technological evolution of the world has drastically changed interactions and communalised knowledge, thus setting up a new challenge for the world education system to meet the needs of the 21st century (Malik, 2018).

The COVID-19 lockdown, which affected numerous sectors in countries worldwide, revealed the lack of adequate infrastructure and intelligent applications in crucial areas such as innovative education, smasrt transportation, driverless vehicles, smart cities, manufacturing, and homes (Civelek & Xiarewana, 2020). Furthermore, COVID-19 resulted in the shut-down of schools across the globe affecting millions of learners, thereby creating pressure on the need for rapid digitalisation of education (Douse, 2021). Thus, it raises concerns about the leadership of schools which has yet to evolve in dealing with the challenges that young people face in the 21st century (OECD, 2009; Malik, 2018), mainly through the lens of sustainability. To meet the challenges of school leadership in the post-digital era, school leadership, in which the tenets of sustainability are entrenched, is highly important. This type of school leadership is expected to be resilient, adaptive, flexible, self-reliant, and intelligent (Burns et al., 2015). Hence, school leadership can only be up to date when it adequately caters for the challenges learners face in the 21st century.

Education for the 21st century ought to be infused with the ideals of the SDGs. Thus, leadership in educational institutions should demonstrate upward leadership to influence the state's policy, lateral leadership to ensure knowledge transfer through collaborations with other schools, and institutional leadership to ensure a supportive and warm environment for the staff (Munby, 2020). Understudying these dynamic demands of 21st century educational leadership is the necessity of an evolving sustainable leadership development that is deliberately focused and strategic over time (Conway, 2015). A new generation of challenges makes leadership development practices inadequate (Iordanoglou, 2018). This study discusses the issues surrounding school leadership development through the lens of sustainability in the post-digital era.

Concept of School Leadership Development

School leaders have prominent roles in determining the overall educational outcomes of schools. It has been suggested that the quality of school leaders is correlated to students' academic success (Tingle et al., 2017). Therefore, it is implied that beyond the contributions of teachers, the school leader has roles that, if maximised, can translate to positive outcomes for learners. Educational leadership is broadly defined as a process of influence school stakeholders to promote an effective learning environment (Hitt & Tucker, 2016; Huber, 2004; Rigby, 2014). School leadership research describes how school leaders shape student achievement through various practices (Hitt & Tucker, 2016). The stakeholders, such as teachers, learners, parents and society, experience all the organisational processes in the school, such as monitoring of the

instructional process, management of the school personnel and allocation of resources to ensure effective running of schools (Daniëls et al., 2019). From a more encompassing perspective, school leadership consists of teachers entrusted with the responsibility of leading the classrooms, the heads of departments and other leading professionals whose activities in the school determine the outcome of instructional processes (Hauge & Norenes, 2014). Hence, it can be concluded that the concept of school leadership is not universally defined. Instead, researchers focus on specific aspects of concern, which are traced to school leaders' activities. This study considers the concept of school leadership from a narrower perspective, which determines school leadership based on monitoring the school processes, determining and allocating resources, and managing the school personnel for effective educational outcomes.

School leadership is an essential element of the school system's functioning due to the role of school principals or heads in strengthening teachers' professional engagements, consequently promoting instructional practices that influence students' achievement (Jayapragas, 2016). Hence, school leaders determine which action a school is embarking on and which direction the school will follow. School leadership structures are examined based on instructional, situational, distributed, and transformational leadership theories (Daniëls et al., 2019). Understanding the leadership structures based on each theory provides a sound framework for defining school leadership. Instructional leadership explains a leadership structure operating the top-bottom approach where principals control and coordinate instruction (Daniëls et al., 2019).

On the other hand, transformational leadership describes a shared leadership model that focuses on collaboration among staff and principals rather than the bottom-top method (Aas, Brandmo, 2016). Distributed leadership is an approach where goals are achieved through communicating missions and goals, proper alignment of structures and resources to support students, actively learning among staff and promoting innovation in teaching and learning (Heck, R., & Hallinger, 2010). The integration of the existing leadership theories led to the leadership strategies of modern times (Daniëls et al., 2019).

School leadership development (SLP) is measured using various metrics such as human capital, executive leadership, instructional leadership, school culture and strategic operations (Tingle et al., 2017). Five forces of leadership recognise leadership in terms of educational, technical, human, symbolic and cultural (Jayapragas, 2016). The concept of "Leadership for Learning" (LL) was developed to meet up with the challenges of instructional leadership (Daniëls et al., 2019). Hence, the concept is integrated with eight dimensions, including a vision for learning, curricular programme, communities of learning, assessment programme, instructional programme, organisational culture, advocacy and resource acquisition and use (Daniëls et al., 2019). Developing leadership capacity in an individual over time has been defined by the term capacity (Miles & Scott, 2019). To lead effectively, a leader needs both the qualities and the abilities to work effectively with others (Negandhi et al., 2015). Effective Leadership Development (LD) is a longitudinal and dynamic process that takes time and many

resources to implement and bear positive outcomes (Joseph-Richard et al., 2021). According to Thi Hoang Yen et al. (2021), the first stage of effective School Leadership Development (SLD) starts when an individual is a teacher until he/she reaches the principal position. Hence, SLD is a career-long process that instils leadership traits among school heads and achieves sustainable educational outcomes. Developing leadership capacity in an individual over time has been defined by the term capacity.

The LD process can be tied to the school principal or the generality which is of school leadership. A SLD process focused on the school principal begins with pre-service training, practical training for first-year principals, training through leadership practice at school, cultivation through the school leader network and participation in training for subordinates or newly appointed school leaders (Thi Hoang Yen et al., 2021). However, this leadership process is only applicable when leadership development coopts teachers who later become school principals (Tingle et al., 2019). Ensuring the efficacy of teachers and principals in solving educational challenges in their schools is determined by the SLD programmes. As a result, SLD prepares teachers and leaders to aspire to lead the school's post-digital educational realities (Fusarelli & Fusarelli, 2018). Church and Rotolo (2010) believe that LD must be driven by internal and external assessment for an educational system to see significant change. Thus, SLD is the process of enhancing a school leader with the ability, competencies and skills to lead effectively.

Educational Sustainability

Sustainable development is stratified into three major pillars: economic sustainability, social sustainability and environmental sustainability (Mensah, 2019). Economic sustainability consists of resource utilisation, production and consumption that ensures equitability while considering other aspects of sustainability (D'Amato et al., 2017; Klarin, 2018). Environmental sustainability is the attempt to protect the environment and conserve life on land, air and water (D'Amato et al., 2017). In contrast, social sustainability ensures equity, participation, empowerment, institutional stability and cultural identity (Mensah, 2019). Social sustainability is an aspect of development that focuses on enhancing people's lives through equitable wealth distribution, less reliance on non-renewable energy and better education (Rosen, 2018). Therefore, educational sustainability is one of the units of social sustainability since education is concerned with developing talents through training to empower people and replace current employees in the future (Kotob, 2015). Education is an integral part of the tools to achieve sustainability because, in the first instance, it fosters, among people of all ages, the awareness, attitudes, knowledge, skills, values and actions to take in ensuring the protection and conservation of the environment. In another instance, education encourages economic sustainability, which promotes equity, social justice and inclusion through the development of talents to increase prosperity, competence, and civic skills and allow for meaningful participation in society (Ferrer-est & Chalmeta, 2021).

Educational sustainability is recognised in the SDGs as an agent of transformation through which individuals can be imbibed with the skills, knowledge, values and attitudes to make positive contributions to the SDGs (UNESCO, 2017). Before the formal adoption of the SDGs in 2015, sustainability was from the perspective of environmental preservation and was the focus of many countries (Rauch & Steiner, 2006). Thus, gave birth to environmental education (EE), which was based on issues such as recycling, saving water, waste separation, reducing plastic usage and saving energy (Rauch & Steiner, 2006). A shift from EE also culminated in education for sustainable development. Education for sustainable development (ESD) or educational sustainability is an approach towards empowering learners to embark on conscious decisions and responsible actions to achieve economic viability, environmental integrity and a just society both in the present and future generations (Kropinova & Krasnov, 2021; UNESCO, 2017). ESD, one of the UN's agents in achieving the SDGs, presents a new challenge to educational managers due to the requirement of restructuring the curriculum, programmes, policies and practices (Ferrer-est & Chalmeta, 2021). As a result, ESD is strategically connected to achieving the trio of individual transformation, societal transformation and technological advances by 2030 (Kropinova & Krasnov, 2021).

In achieving the objectives of its formulation, educational sustainability is imbibed with the constructivist tradition in which students create knowledge, participate in an interactive learning environment and address real environmental challenges (Marouli, 2021). The major issues surrounding educational sustainability are lack of knowledge or awareness about the principles of sustainable development, resistance to change, poor perception of sustainability, lack of resources, overcrowded curriculum and lack of support from the senior management (Ferrer-est & Chalmeta, 2021). Thus, to attain educational sustainability requires the development school leaders with relevant skills and capacities that will provide them with the opportunity to lead sustainable schools.

Leading Schools in Post-Digital Era

There is a rapid globalised change in the work world due to technological and scientific advances, global economic challenges and social changes (Seinhaus, 2022). While the service industry is expanding worldwide, there is a gradual elimination of human activities in manufacturing industries that used to be labour-intensive in the 20th-century (Malik, 2018). As a result, the 21st-century work environment demands a newer form of expertise than what it took to be employed in the 20th-century. Hence, global citizens in the 21st-century workplace environment are expected to be individuals who can use a wide range of electronic technologies to synthesise and apply information, think creatively and critically solve problems through collaborations and cross-cultural approaches to education (Malik, 2018; van Laar et al., 2020). These, therefore, demand a different education system from the traditional knowledge-imputing education the world is used to and leadership skills set for the new era.

Post-digitalisation, or the post-digital era, is currently under development but is nonetheless defined as the displacement of analogue technologies to digital and virtual technologies (Hueso-Romero et al., 2021). Post-digitalisation "implies pervasive and ubiquitous digitalisation" (Parmiggiani et al., 2020, p. 587). "post-digital means paradise—a society in which we can escape digital technology's surveillance technology and our growing digital shame" (Parmiggiani et al., 2020, p. 587). Post-digital education in the post-pandemic period involves self-directed and self-regulated learning, virtualisation and hybridisation of classrooms, assessment in the form of personalised feedback, universal connectivity and emphasis on learners' responsibility and schools' roles in strengthening the social process (Douse, 2021). The new normal, created by ESD, triggers innovation and changes in school, which school leaders must be fully prepared to develop (Rauch & Steiner, 2006). A significant aspect of school leadership heavily affected by this gap includes school development and management practices, which are still in their infancy.

The post-digital era is marked by the ubiquity of digital and computerised technologies, permanent connectivity and a technology-inclined social system which has become imbibed into the global culture (Hueso-Romero et al., 2021). The post-digital era is an age of intelligent systems and machines. Artificial Intelligence (AI) is becoming integrated into industrial production and healthcare services and a part of the education system. According to Douse (2021), education has moved to a point where developers are now tasked to develop AI tools which claim to teach better than teachers or augment teachers' capacity for maximum instructional efficiency. The use of AI tools such as ChatGPT will influence learning and assessments and is unavoidable requiring leaders to be responsive and adaptive. For instance, the work of Nguyen (2022) shows that ChatGPT would avail students reasonable and free accessibility to enabling tools for the completion of academic tasks in a stress-free manner. However, concerns yet remain on the part of educators who are of the opinion that ChatGPT would encourage laziness, lack of critical thinking and academic theft among students (Nguyen, 2022). Suffice to state that as much as Chart GPT is to be considered useful and laudable, caution is to be taken where necessary and possible to avoid the tool being an instrument promoting laziness and academic disintegrity. Meanwhile, the COVID-19 pandemic heightened the world's gradual move to a post-digital world where massive open online courses (MOOCs) and virtual and hybrid learning spaces became the order of the day (Savva & Souleles, 2020). With the new system, teachers and learners can visit, discover, collaborate, and learn in creative harmony together (Douse, 2021). As a result, learners are no longer seen as passive recipients of instructions. Instead, they collaborate with a leadership system willing to play a supportive role, providing a stimulating environment for learners to share experiences and learn together (Douse, 2021).

It is essential to critically explore the changing nature of education within the spaces of institutions of learning especially considering the "…new pedagogies that draw on the potentialities of technology, the flow of data, and the massive amount of academic material that

can be accessed online" (Lamb et al., 2022, p.1). According to Lamb et al. (2022), one of the reasons for the exploration of the changing nature of education in this era is based new practices brought about by the outbreak of the COVID-19 pandemic. Suffice it to state that the pandemic has fast-forwarded expected happenings in the digital and post-digital era in the field of education. Thus, Rapanta et al. (2021) state that "…COVID-19 pandemic has presented an opportunity for rethinking assumptions about education in general … (p. 715)." In congruence, Singh et al. (2021) view it from the angle of promoting hybridity and blended forms of learning. Örtegren (2022) study showed that training teachers to adapt and function appropriately following the demand of the post-digital era is paramount. However, challenges affecting the preparation of teachers for such an era include issues such as lack of time and unclear degree objectives (Örtegren, 2022). "Leading for learning, emotional intelligence, critical thinking, communication and ethics, collaboration, decision making and problem solving, digital dexterity and entrepreneurial" are key school leadership competencies required for leading sustainable schools in the post-digital era (Kin et al., 2020).

Similarly, Grushka, et al. (2022), alluding to the post-digital era, state that "Classroom culture faces an existential threat to the traditional ways of teaching and engaging student learning- for teachers to reassess their *strategies is going to be hugely challenging* (p. 20, italics added for emphasis). The preceding implies that while there are possibilities in the post-digital era, there are challenges and supposedly likely impossibilities just like any other era. However, for institutions of learning to be relevant and align with the post-digital era, there is a need to rethink revise current practices, and develop school leaders. For instance, according to Lamb et al. (2022), alluding to the work of Lamb and Ross (2021), the Twitter conversation is considered a useful tool concerning lecture capture technologies. Meanwhile, Lamb et al. (2022), hold the view that it is of value and hence valid to understand and consider social media as one of the educational environments, thus, adopt its practices for useful educational purposes. Lubicz-Nawrocka and Owen, (2022) call for a revision of the curricula guiding teaching and learning in learning institutions. As part of student engagement, curriculum co-creation is required. Through dynamic interaction between staff and students, curriculum content, structure, and processes are developed. Students' learning experiences inform and influence this interaction (Lubicz-Nawrocka & Owen, 2022; Bovill, 2020; Lubicz-Nawrocka, 2019). For instance, Lubicz-Nawrocka and Owen (2022), alluding to the need for and benefit of curriculum and co-creation, state that "Curriculum co-creation and student-staff partnerships *promote high levels of student and staff engagement, which often occur through staff inviting students to take more active roles in shared decision-making*" (p. 794). Thus, it shows the need to revise the curricula guiding activities in learning institutions.

Surmise to state that there is a need for adjustments to the changes experienced in the post-digital era. Thus, by extension, adjustments are envisaged in how institutions of learning are to be led during the era. Moreover, according to Readytech (n.d), leadership in the digital era differs from regular traditional leadership. Hence, "Digital leaders need a level of fluency with

technology. Rather than outsourcing everything wholesale to a vendor or an IT team, they need to be comfortable with what best practice looks like and the potential for technology within the organisation (par. 13).” Therefore, it suggests that leaders' roles before the post-digital era differ from what is expected during the post-digital era. This accounts for the next section, which presents the implications and needs for school leadership development to ensure sustainable development.

Implications of school leadership development for sustainable development in the Post-Digital Era

School leadership is pivotal to sustainable community development (Mogaji & Newton, 2020) especially considering the roles expected to be performed by learning institutions in enhancing desired progress (Harber & Mncube, 2011). This corroborates the words of President Nelson Mandela, cited by USAID (2013), which states that "education is the most powerful weapon which you can use to change the world (par. 1)." This suggests the potency of education in enhancing sustainable development in society. In this instance, school leaders' role(s) becomes critical. School leadership development is critical to maintaining intra-school relationships and the school's relationship with the community and other stakeholders (Fusarelli & Fusarelli, 2018). Khumalo (2019) the view that school leaders such as principals have the capability in their position to "…promote t*he culture of commitment* and therefore a foundation for sustainable development is laid (p. 22)." Thus, if well managed, school leaders can be an antecedent to the desired sustainable development (Khumalo, 2019). This accounts for the need for school leaders to be well-trained, oriented, reitrained, and capacitated to support the promotion of sustainable development in the post-digital era beginning from the institutions of learning that they lead, the host communities and their environs.

A review of the work of Desfandi & Maryani (2016) shows that, for schools to be well positioned to be able to contribute to sustainable development in the communities, their leaders are expected to have a high level of commitment towards the community, be good role models and motivators. Meanwhile, according to Kanyimba et al. (2015), the happenings in the institutions of learning are aligned with the sustainable development policy(s). Thus, policies aiding sustainable development in the communities must be reviewed and made to function congruently with learning institutions' practices. This accounts for the reason why scholars such as Zwolińska et al. (2022), González (2021), and Veinovic (2017) call for the revision of curricula of institutions of learning. Hence, school leaders' roles go beyond school activities if they are to promote and lead for sustainability in the community. Therefore, the success of a school in achieving its educational and community objectives lies in ready, effective leadership. Considering the dynamism in the world of post-digital education and sustainability, several implications can be drawn for school leadership development. Firstly, school leaders should ensure post-training development and continuation of learning (Thi Hoang Yen et al., 2021). This will initiate a leadership development process of adaption to new challenges and new learning situations in schools. Continuous leadership development is important to create a

dynamic environment that is productively engaged in accelerating digital transformation, using leadership factors such as leadership style and approaches, strategic planning and knowledge (Ziadlou, 2021).

The emergence of ESD and the digitalisation of the societal implies a new leadership system for educational institutions. According to Mogaji & Newton (2020), sustainable education requires that school leaders are capable of managing changes needed for reorientation of students in line with the goals of the SDGs. These changes are integrated into the procedures, plans, curriculum, policies and goals (Mogaji & Newton, 2020). Therefore, SLD must imbibe in their programmes sustainability actions and values that encourage inclusion, collaborative learning, problem solving and reflective process (Burns et al., 2015). Hence, sustainable school leadership of the current epoch is expected to involve facilitation rather than instructional leadership of the traditional sense. Leadership attributes that recognise collaboration and community building among teachers and learners tend to prepare learners to be enthusiastic and active citizens ready to thrive in an interconnected world (Marouli, 2021).

Previously, school learning outcomes were based on factors other than teachers' and school leaders' characteristics. In modern times, however, school leaders now take accountability for learning outcomes for students and teachers (OECD, 2009). Therefore, leadership development experts and policymakers must design plans to recognise teachers' and other school leaders' individual preferences and aspirations (Avidov-Ungar, 2016). The recognition of preferences and individuality is a prerequisite to fulfilling the ideals of sustainability, which the school leaders would transfer to the staff and students in their schools.

According to Munby (2020), specific post-digitalised leadership skills needed in schools include problem-solving and practical leadership skills such as chairing a meeting, providing supportive and challenging feedback to colleagues, holding difficult conversations, communicating in large groups and building trust in a team. For Conway (2015), sustainable leadership have certain leadership principles which must be inculcated into SLD programmes. These leadership principles include students’ relationship with the school leaders, promotion of diversity, leadership resourcefulness, proactive leadership and social justice. Thus, school leaders are to be equipped with relevant competencies such as ICT related skills, emotional intelligence skills, collaborative skills, resilience skills, adaptive and human relation skills, critical thinking skills, computational skills, problem-solving, and creativity skills to lead schools for sustainable development in the post-digital era.

Conclusion

In sustainable education, students create knowledge, participate in an interactive learning environment and address real-world environmental issues in post-digitised world. A post-digital world is one where intelligent systems and machines provide sustainable education services using artificial intelligence (AI) and other technologies. A successful SLD process requires time and many resources to implement and bear positive results. As a result, SLD involves developing the abilities, competencies, and skills of school leaders to bring possible transformation in changing world of technologies. With digital and computerised technologies omnipresent, permanent connections, and a technology-inclined social system infused into global cultures, the pre-digital era has been profoundly transformed. School systems are an integral part of the changing world, thus, to ascertain sustainable education, school leaders require relevant skills and competences to lead schools in the post-digital world. A good school leader must have skills and knowledge to be a good role model and motivator in a sustainable era. In order to achieve sustainable education, school leaders must be able to reorient students according to SDG goals. Therefore, continuous SLD is crucial to create an environment that accelerates digital transformation using factors such as leadership style, strategic planning, and knowledge management.

The study is limited to theoretical and philosophical views; thus, empirical studies can be carried out to validate the role of leadership development on sustainable schooling in the post-digital era. Also, systematic reviews can be done to ascertain the level and nature of leadership development in the post-digital epoch. Lastly, further research can be conducted in order to find a leadership development model/s that are viable to prepare school leaders for educational sustainability.

References

Aas, M., & Brandmo, C. (2016). Revisiting instructional and transformational leadership. *Journal of Educational Administration, 54*(1), 92–110. https://doi.org/10.1108/JEA-08-2014-0105

Avidov-Ungar, O. (2016). A Model of Professional Development: Teachers' Perceptions of Their Professional Development. *Teachers and Teaching: Theory and Practice, 22*(6), 653–669. https://doi.org/10.1080/13540602.2016.1158955

Barbosa, G. S., Silva, G., & Politécnica, E. (2014). A Conceptual Review of The Terms Sustainable Development and Sustainability. *International Journal of Social Sciences, III*(2), 1–15. https://www.iises.net/download/Soubory/soubory-puvodni/pp-01-15_ijossV3N2.pdf

Burmeister, M., & Eilks, I. (2013). An understanding of sustainability and education for sustainable development among German student teachers and trainee teachers of chemistry. S*cience Education International, 24*(2), 167–194. ERIC. Retrieved October 2022. https://files.eric.ed.gov/fulltext/EJ1015833.pdf

Burns, H., Vaught, H. D., & Bauman, C. (2015). Leadership for sustainability: Theoretical foundations and pedagogical practices that foster change. *International Journal of Leadership Studies, 9*(1), 88-100. http://www.regent.edu/acad/global/publications/ijls/new/home.htm

Chin, C. K., Munip, H., Miyadera, R., Thoe, N. K., Ch'ng, Y. S., & Promsing, N. (2019). Promoting education for sustainable development in teacher education integrating blended learning and digital tools: An evaluation with exemplary cases. *Eurasia Journal of Mathematics, Science and Technology Education, 15*(1), 1–17. https://doi.org/10.29333/ejmste/99513

Civelek, M. E., & Xiarewana, B. (2020). Effects of COVID-19 on China and the world economy: Birth pains of the post-digital ecosystem. *Journal of International Trade, Logistics and Law, 6*(1), 147–157. https://ssrn.com/abstract=3611537

Conway, J. (2015). Sustainable leadership for sustainable school outcomes: Focusing on the capacity building of school leadership. *Leading and Managing, 21*(2), 29–45. https://research.usq.edu.au/item/q34y4/sustainable-leadership-for-sustainable-school-outcomes-focusing-on-the-capacity-building-of-school-leadership

D'Amato, D., Droste, N., Allen, B., Kettunen, M., Lähtinen, K., Korhonen, J., Leskinen, P., Matthies, B. D., & Toppinen, A. (2017). Green, circular, bio economy: A comparative analysis of sustainability avenues. *Journal of Cleaner Production, 168*, 716–734. https://doi.org/10.1016/j.jclepro.2017.09.053

Daniëls, E., Hondeghem, A., & Dochy, F. (2019). A review on leadership and leadership development in educational settings. *Educational Research Review, 27*, 110–125. https://doi.org/10.1016/j.edurev.2019.02.003

Desfandi, M., Maryani, E., & Disman, D. (2016, August). The role of school principal leadership in implementation of eco school program as the effort to support sustainable development. In *6th International Conference on Educational, Management, Administration and Leadership* (pp. 197-200). Atlantis Press. https://doi.org/10.2991/icemal-16.2016.40

Douse, M. (2021). Let the learners lead: The worldwide transition into post-digital age, post-pandemic education. *Educational Planning, 28*(4), 63–75. Eric. Retrieved November 12, 2022. https://files.eric.ed.gov/fulltext/EJ1338310.pdfhttps://files.eric.ed.gov/fulltext/EJ1338310.pdf

Ferrer-est, M., & Chalmeta, R. (2021). Integrating Sustainable Development Goals in educational institutions. *The International Journal of Management Education, 19*(March). https://doi.org/10.1016/j.ijme.2021.100494

Fusarelli, B. C., & Fusarelli, L. D. (2018). Leadership development in rural schools : An innovative training model. *Literacy Information and Computer Education Journal, 9*(1), 2842–2847. https://infonomics-society.org/wp-content/uploads/licej/published-papers/volume-9-2018/Leadership-Development-in-Rural-Schools-An-Innovative-Training-Model.pdf

González, E. P. (2021). Toward education for sustainable development: Lessons from Asia and the Americas. *In Curriculum and learning for climate action* (pp. 291-308). Brill. Leiden, The Netherlands: Brill. doi: https://doi.org/10.1163/9789004471818_019

Grushka, K., Lawry, M., Chand, A., & Devine, A. (2021). Visual borderlands: Visuality, performance, fluidity and art-science learning. *Educational Philosophy and Theory*, *54*(4), 404-421. https://doi.org/10.1080/00131857.2020.1859368

Harber, C., & Mncube, V. (2011). Is schooling good for the development of society?: The case of South Africa. *South African Journal of Education*, *31*(2), 233-245. https://doi.org/10.15700/saje.v31n2a483

Hauge, T. E., & Norenes, S. O. (2014). School leadership and educational change : Tools and practices in shared school leadership development. *Journal of Educational Change, 15*, 357–376. https://doi.org/10.1007/s10833-014-9228-y

Heck, R., & Hallinger, P. (2010). Collaborative leadership effects on school improvement: Integrating unidirectional- and reciprocal-effects models. *The Elementary School Jour- Na, 111*(2), 226–252. https://www.journals.uchicago.edu/doi/epdf/10.1086/656299

Hitt, D. H., & Tucker, P. D. (2016). Systematic review of key leader practices found to influence student achievement: A unified framework. *Review of Educational Research, 86*(2), 531–569. https://doi.org/10.3102/0034654315614911/FORMAT/EPUB

Hueso-Romero, J. J., Gil-Quintana, J., Hasbun, H., & Osuna-Acedo, S. (2021). The social and transfer massive open online course: Post-digital learning. *Future Internet, 13*(5), https:/m/doi.org/10.3390/fi13050119

Iordanoglou, D. (2018). Future trends in leadership development practices and the crucial leadership skills. *Journal of Leadership, Accountability and Ethics, 15*(2), 118-129. https://doi.org/10.33423/jlae.v15i2.648

Jayapragas, P. (2016). Leaders in education program: The Singapore model for developing effective principal-ship capability. *Current Issues in Comparative Education (CICE), 19*(1), 92–108. https://doi.org/10.52214/cice.v19i1.11537

Joseph-Richard, P., Edwards, G., & Hazlett, S. A. (2021). Leadership development outcomes research and the need for a time-sensitive approach. *Human Resource Development International, 24*(2), 173–199. https://doi.org/10.1080/13678868.2020.1815155

Kanyimba, A. T., Katewa, E. N., & Claassen, P. (2015). The contribution of education for sustainable development to transformational leadership among selected Namibian school principals. *Open Journal of Social Sciences*, *03*(03), 186-196. https://doi.org/10.4236/jss.2015.33028

Khumalo, S. S. (2019). The role of transformational school leadership in promoting teacher commitment: An antecedent for sustainable development in South Africa. *Discourse and Communication for Sustainable Education*, *10*(2), 22-32. https://doi.org/10.2478/dcse-2019-0015

Kin, T. M., Kareem, O. A., Musa, K., Ghouri, A. M., & Khan, N. R. (2020). Leading sustainable schools in the era of Education 4.0: Identifying school leadership competencies in Malaysian secondary schools. *International Journal of Management in Education, 14*(6), 580–610. https://doi.org/10.1504/ijmie.2020.110690

Klarin, T. (2018). The concept of sustainable development: from its beginning to the contemporary issues. *Zagreb International Review of Economics & Business, 21*(1), 67–94. https://doi.org/10.2478/zireb-2018-0005

Kotob, F. (2015). What Is Sustainability? (Issue November 2011, pp. 1–14).

Kropinova, E., & Krasnov, E. (2021). Students, the next steps for the baltic universities' cooperation in accordance with the development of education and the upbringing of students. In E. V Krasnov & D. V Gaeva (Eds.), *Innovations and Traditions for Sustainable Development* (pp. 109–126). https://doi.org/10.1007/978-3-030-78825-4

Lubicz-Nawrocka, T., & Owen, J. (2022). Curriculum co-creation in a postdigital world: advancing networked learning and engagement. *Postdigital Science and Education, 4*(3), 793–813. https://doi.org/10.1007/S42438-022-00304-5/METRICS

Lubicz-Nawrocka, T. M. (2019). "More than just a student": How co-creation of the curriculum fosters third spaces in ways of working, identity, and impact. *International Journal for Students as Partners*, *3*(1), 34-49. https://doi.org/10.15173/ijsap.v3i1.3727

Malik, R. S. (2018). Educational challenges in 21st century and sustainable development. *Journal of Sustainable Development Education and Research, 2*(1), 9–20. https://doi.org/10.17509/jsder.v2i1.12266

Marouli, C. (2021). Sustainability education for the future? Challenges and implications for education and pedagogy in the 21st century. *Sustainability (Switzerland), 13*(5). https://doi.org/10.3390/su13052901

Mensah, J. (2019). Sustainable Development: Meaning , history , principles , pillars , and implications for human action : Literature review principles , pillars , and implications for human action : Literature review. *Cogent Social Sciences, 5*(00). https://doi.org/10.1080/23311886.2019.1653531

Michelsen, G., & Fischer, D. (2017). Sustainability and education. In M. von Hauff & C. Kuhnke (Eds.), *Sustainable Development Policy: A European Perspect* (1st Editio, pp. 135–158). Routledge. https://doi.org/https://doi.org/10.4324/9781315269177

Miles, J. M., & Scott, E. S. (2019). A new leadership development model for nursing education. *Journal of Professional Nursing, 35*(1), 5–11. https://doi.org/10.1016/j.profnurs.2018.09.009

Mogaji, I. M., & Newton, P. (2020). School leadership for sustainable development: A scoping review. *Journal of Sustainable Development, 13*(5), 15. https://doi.org/10.5539/jsd.v13n5p15

Munby, S. (2020). The development of school leadership practices for 21st century schools. *European Journal of Education, 55*(2), 146–150. https://doi.org/10.1111/ejed.12394

Negandhi, P., Negandhi, H., Tiwari, R., Sharma, K., Zodpey, S. P., Quazi, Z., Gaidhane, A., Jayalakshmi N, Gijare, M., & Yeravdekar, R. (2015). Building interdisciplinary leadership skills among health practitioners in the twenty-first century: An innovative training model. *Frontiers in Public Health, 3*(October), 1–7. https://doi.org/10.3389/fpubh.2015.00221

Nguyen, N. (20 December 2022). *ChatGPT: A threat to education? (Opinion).* Feedback Fruit. https://feedbackfruits.com/blog/chatgpt-a-threat-to-education-opinion

OECD. (2009). Improving school leadership: The Toolkit.

Örtegren, A. (2022). Digital citizenship and professional digital competence — Swedish Subject teacher education in a postdigital era. *Postdigital Science Education, 4*, 467–493. https://doi.org/10.1007/s42438-022-00291-7

Parmiggiani, E., Teracino, E. A., Huysman, M., Jones, M., Mueller, B., & Mikalsen, M. (2020). Oasis 2019 panel report: A glimpse at the "post-digital." In C*ommunications of the Association for Information Systems* (Vol. 47, Issue 1). https://doi.org/10.17705/1CAIS.04727

Rapanta, C., Botturi, L., Goodyear, P., Guardia, L., & Koole, M. (2021). Balancing technology, pedagogy and the new normal: Post-pandemic challenges for higher education. *Postdigital Science and Education, 3*(3), 715–742. https://doi.org/10.1007/s42438-021-00249-1.

Rauch, F., & Steiner, R. (2006). School development through education for sustainable development in Austria. *Environmental Education Research, 12*(1), 115–127. https://doi.org/10.1080/13504620500527782

Rosen, M. A. (2018). Issues, concepts and applications for sustainability. Glocalism: J*ournal of Culture, Politics and Innovation, 3*, 1–21. https://glocalismjournal.org/wp-content/uploads/2019/02/Rosen_gjcpi_2018_3.pdf

Savva, S., & Souleles, N. (2020). "Education without borders": addressing online learning and inclusion through the lens of Museum Affinity Spaces (MAS). *Cultural management and policy in a post-digital world–navigating uncertainty*, 183. ENCATC: Belgium https://www.encatc.org/media/5620-ebook-of-proceedings_encatc-annual-congress-2020_final.pdf

Seinhaus, N. (2022). Of "Lighthouses", "Living Labs" and the "Wisdom of the Crowd" - Social responsibility beyond research and teaching (an NGO perspective). In Higher Education in the World Report 8 Special Issue New Visions for Higher Education towards 2030. www.guni-call4action.org

Sergiovanni, T. J. (2009). *The principalship: A reflective practice perspective.* Pearson. https://www.pearson.com/en-us/subject-catalog/p/principalship-the-a-reflective-practice-perspective/P200000001816/9780133261714

Singh, J., Steele, K., & Singh, L. (2021). Combining the best of online and face-to-face learning: hybrid and blended learning approach for COVID-19, post vaccine, & post-pandemic world. *Journal of Educational Technology Systems, 50*(2), 140–171. https://doi.org/10.1177/00472395211047865

Thi Hoang Yen, D., Phuong Huyen, N., Thi Duong, N., Huy Hoang, N., H Y, D. T., & H, N. P. (2021). The process of developing leadership competencies for high school principals- insights from vietnamese case. E*ducational Sciences: Theory & Practice, 21*(2), 27–43. https://doi.org/10.12738/jestp.2021.2.003

Tingle, E., Corrales, A., & Peters, M. L. (2019). Leadership development programs: investing in school principals. *Educational Studies, 45*(1), 1–16. https://doi.org/10.1080/03055698.2017.1382332

UN. (2019). Global Sustainable Development Report 2019: The Future is now – science for achieving sustainable development. In Global Sustainable Development Report 2019. United Nations. https://sdgs.un.org/gsdr/gsdr2019

UNCED. (1993). Agenda 21: Programme of action for sustainable Development; Rio declaration on environment and development ; statement of forest principles: The final text of agreements negotiated by governments at the United Nations Conference on Environment and Devel. United Nations Conference on Environment and Development Rio de Janeiro, Brazil. 1992, 3–14. https://sustainabledevelopment.un.org/content/documents/Agenda21.p

UNESCO. (2017). *Education for sustainable development goals: learning objectives*. United Nations Educational, Scientific and Cultural Organization Publishing. https://unesdoc.unesco.org/ark:/48223/pf0000247444 https://unesdoc.unesco.org/ark:/48223/pf0000247444

USAID. (2013, April 23). *Education: The most powerful weapon for changing the world | USAID impact*. USAID Impact | The Official Blog of the U.S. Agency for International Development. https://blog.usaid.gov/2013/04/education-the-most-powerful-weapon/

van Laar, E., van Deursen, A. J. A. M., van Dijk, J. A. G. M., & de Haan, J. (2020). Determinants of 21st-Century skills and 21st-Century digital skills for workers: A systematic literature review. *SAGE Open, 10*(1), 1–14. https://doi.org/10.1177/2158244019900176/FORMAT/EPUB

Veinović, Z. (2017). The curricula revision in the context of education for sustainable development: From the perspective of two primary school subjects' curricula. *Zbornik Instituta za pedagoska istrazivanja, 49*(2), 191-212. https://doi.org/10.2298/ZIPI1702191V

Ziadlou, D. (2021). Strategies during digital transformation to make progress in achievement of sustainable development by 2030. In L*eadership in Health Services*. Emerald Publishing Limited. https://doi.org/10.1108/LHS-08-2020-0056

Zwolińska, K., Lorenc, S., & Pomykała, R. (2022). Sustainable development in education from students' perspective—Implementation of sustainable development in curricula. *Sustainability*, *14*(6), 3398. https://doi.org/10.3390/su14063398

STRUGGLES AND TRIUMPHS OF AN EARLY CHILDHOOD STEM EDUCATOR: WHY CONNECTIONS MATTER? AN INTERVIEW WITH MS. JADE LEONG

POH TAN
Simon Fraser University

JADE LEONG
Senior Early Childhood Educator

Abstract

This interview between a researcher and an early childhood educator delves into pedagogical approaches for teaching STEM subjects to young children aged 1 to 5 years. The conversation emerges from collaborations and reflections, shedding light on the challenges and solutions within early childhood education. Research by Buechel (2021) emphasizes the importance of STEM training for teachers, as it correlates with increased confidence and implementation rates. Additionally, the impact of teacher self-efficacy and experience on classroom performance and motivation is evident through studies by Katzenmeyer & Lawrenz (2006) and Smith, Douglas, & Cox (2009). The interview highlights a significant issue—early childhood educators often lack in-depth professional preparation in math and science. This knowledge gap results in insufficient content expertise and a lack of confidence in delivering high-quality STEM education.

*Figure SEQ Figure * ARABIC 1. Ms. Jade Leong, Senior Early Childhood Educator. Photo Credit: Used with Permission.*

This is an interview distilled from conversations, collaborations, and reflections between a researcher (Poh) and an early childhood educator (Jade) on understanding and exploring pedagogical approaches to teaching Science, Technology, Engineering, and Math (STEM) in an early childhood classroom setting. In this interview, early years includes children between the age of 1 to 5 years. Research published by Buechel (2021), concluded that "higher training in STEM resulted in higher confidence in teachers' ability which in turn resulted in higher rates of implementation" (p. 2). Other studies also show that teacher self-efficacy and experience affects performance in the classroom (Katzenmeyer & Lawrenz, 2006, Smith, Douglas, & Cox, 2009), and thus motivation, and confidence. Furthermore, research "show that early childhood educators rarely receive in-depth professional preparation in math and science, resulting in insufficient content knowledge and lack of confidence in their own abilities to implement high quality STEM learning experiences for young learners" (Brenneman, 2009, Greenfield, 2009, cited in Brenneman K. L., 2019). Jade's struggles with bringing STEM into her practices reflected similar challenges to her colleagues and others in the field. In this interview, Jade shares her reflections and her journey toward gaining more confidence to bringing and engaging with STEM with her students with support from the researcher who is a scientist and science educator, and more importantly, from other educators and the community, which includes volunteers from a science museum and the university.

Poh: My name is Poh, and I am a science education researcher in the Faculty of Education at Simon Fraser University. I am interviewing Ms. Jade Leong about the challenges that she experiences as an early childhood educator in bringing STEM into her teaching practice. I will be asking Jade about her reflections, experiences, and challenges on balancing between her passion for STEM education and commitments to everyday tasks as an early childhood educator. Jade, thank you for taking your time to share your experiences with me. I am so glad we get to continue our work together after publishing our visual scholarship piece (Tan & Leong, 2021). Let's start by telling me a little bit about yourself, your background and how you came to be an early childhood educator?

Jade: Since finishing high school, I was unsure of what career path to take. My mom suggested to work with children because she saw a caring nature in me. Throughout elementary school, I often enjoyed spending time with children who were younger than me. I decided to explore early childhood education by attending an adult continuing studies information session at a community center. I learned that the first few years of their lives were vital and crucial to their overall

development. Specifically, I was drawn to the journey of how early childhood educators build close relationships with the children that go beyond rote learning. This was the start of a new chapter of my life. I've been working as an Early Childhood Educator for six years with extended training and experience in special needs and inclusive practice.

Poh: It is interesting to hear about how your family helped you discover your strength and interests. Tell us about how you became interested in STEM education? Were you always interested in science?

Jade: As an adult, I found science to be very important in the way of life as we go through various changes without realizing it. Such as how much the weather is affected by climate change, the concept of gravity or how mixing certain things together, aren't always meant to be together. This notion of questioning the things around you is what inspires children every day with their innate curiosity of the world. I previously worked in a daycare, and it was British Columbia's first living building. The living building was built on a concept that promotes sustainable practices where its design contributes positively to the environment. I became more interested in learning about the sustainability of the building and how it translates or presents itself to the children's learning and thinking around sustainability.

Poh: As you know, many educators like yourself closely align with a specific pedagogy, what's yours and what are your approaches to bring STEM to the children?

Jade: My teaching philosophy aligns with the Reggio-Emilia approach. Regio Emilia was created by Loris Malaguzzi, in the city of Reggio-Emilia in Italy. He theorized that learning and teaching with children needs to go beyond simple transmission of knowledge and instead, he emphasizes that teaching and learning is a co-collaborative, co-creative, and co-constructing process. This includes documenting children's work by using different mediums and allowing space and time for teachers to communicate and continue the co-partnership process. The center I used to work in was inspired by Loris's approaches. In addition to Reggio-Emilia philosophy of child-centredness, I also believe the educator plays a crucial role in a young learner's journey. Therefore, in my pedagogical teaching, I choose to be a facilitator in the children's learning by using provocations to evoke a co-learning partnership with the child. I am intentional when planning explorations that give way to multiple mediums and materials for the children to discover deeper learning within themselves. I understand that children have unique and diverse abilities, backgrounds and cultures that embody their own thoughts, feelings, and opinions. Children have their own identities. This is the lens I look through even when I am teaching STEM.

Poh: It sounds like when you are introducing STEM that respects diverse creative expressions of learning, you are combining science and art. Would you say that you are teaching more from a Science, Technology, Engineering, Arts, and Math (STEAM) approach?

Jade: I'd like to think we strive as educators to teach something from a holistic view that embodies all the approaches to appeal to a vast range of children. I am not sure about acronyms and wasn't really introduced to STEM and STEAM until we chatted previously. But yes, STEAM could bring a more holistic view to learning about science for the children.

Poh: I really like how well thought out your teaching philosophy is. I'd like to ask you a little more about how your philosophy translates into your practice.

Jade: One of the main things we want to strive for in our curriculum is the sense of community. How do the things we cultivate with children impact their understanding of the world? We are not teachers who fill children with knowledge but want them to learn on their own and come up with their own ideas around knowledge and specifically, what they hold as important. When children present the little moments where they find and develop deeper relationships with entities that aren't solely human (animals, nature, inanimate objects), those are moments that I find magical. One example that I can think of how I put my teaching philosophy to practice is that I think about weekly explorations where I and other educators ask the children's questions to guide them to ask deeper questions. We have discussions, drawings, movement, and activities around concepts such as time, change, power, health, and death.

Poh: I really commend you in staying authentic and intentional when you merge your teaching philosophy with your practice. Through my research with observation and conversations with other early childhood educators, I understand that it is hard for some to maintain their authentic identity as an educator, in other words, staying true to your teaching philosophy. In your years of being an educator, have you experienced times when you found it difficult to keep your practice consistently aligned with your philosophy, especially when you are teaching STEM?

Jade: Developing an in-depth teaching philosophy, for all subjects and not just for STEM, requires time, dedication, motivation, resources, and a willingness to commit. Through the eight years I've been in the early childhood education field, I have had many moments where I struggled being authentic, what I am saying is keeping up with teaching from an authentic place, and like many educators, as years passed me by, I became stagnant; finding that some days felt like I was just there but not present in the moment. So, yes, on some days I do struggle with being consistent with staying true to my practice and on those days, it is easier to just set up activities without being intentional simply just to get through the days. This is because to come up with meaningful intentionality for every activity must be well thought-out and planned and aligned with the curriculum. On those days, I am just waiting to go home. When it comes to STEM activities, it requires even more time and energy to plan because I want to make sure that it fits with the existing centers at the school and more so, it is not my expertise. I know that you asked me specifically about STEM, but these struggles are with every topic we try to do.

Poh: I can see how it's not limited to teaching STEM, but in general, teaching. How did you get over these moments?

Jade: Yes, it's not only STEM, but for me, STEM takes more effort and time. How I got over these moments? Well, the only way I could change my mindset was to build on my own self-fulfillment. I started by reading articles that questioned my practice and adapted my philosophy from what it once was to a better understanding of what it is now. It's only possible when you have a team that grows alongside you who also realizes their own interpretation and are motivated to take on challenges with you. I would say that the relations I felt with the other teachers helped me reinforce my identity as an educator and furthermore, gave me confidence to bring STEM to the children. From overcoming my own hurdles, I realize how important it was for me to have connections with people who have similar interest, and this includes people who are not early childhood educators. From my experiences in other facilities, educators who don't have the support, connections, and relations, often feel unappreciated and undervalued. This negatively affects their motivation, dedication, and willingness to commit to further develop their teaching. When there is a lack of support or understanding from management, educators tend to experience a toxic environment between staff (i.e., gossip and rumours), an increase in turnovers and lack of care experienced by families. When educators feel this way, it will affect how they plan activities, what they want to share and what they want to teach. What I mean is that the activities and materials often become closed ended because teachers are no longer motivated to think with intentionality. This tends to impact the children negatively as well because they become bored easily and can lead to negative behaviours.

Poh: I am amazed by the steps you've taken to overcome these emotional struggles that can really impede learning with the children and relating to your colleagues. I can also say that your mindset can also apply to other educators who are not necessarily in the early years. As we've briefly mentioned in the beginning about the importance of not only staying authentic to your teaching practices, but also to create and maintain the relations that you've formed with your entire support system. Can you tell me more about this?

Jade: Having a team with a strong relationship to challenge and question the way you practice not only supports you in the long run but can fulfill you to achieve more. When educators encounter a problem, they are encouraged to discuss it, add to it and critically reflect on their self on what makes it so meaningful to them. We are continually questioning our values and influences that affect the way we think and why our reasoning is "sound" but you can evolve or adapt without losing your own voice. Members of management encourage you to take the benefit of paid workshops and professional development to continually inspire you, create an intrinsic motivation as well as a better state of mind when working with children for years.

Poh: All that you've said has been so insightful and I am sure all educators who read this interview can appreciate and maybe even identify and sympathize with what you've experienced. For the readers who may have the same struggles as you, what would you say to them?

Jade: When educators take time to critically reflect upon their practice, they need to feel encouraged to dedicate spaces to make that time available in the day. They will naturally feel motivated and a willingness to commit when they see the impact it has on their children they work with daily. The children are more engaged in activities; feel more attentiveness to wonderings and questions and will display more acts of mean making when discussing their ideas with you. As an educator, you might feel a newfound eagerness to discover with the children when actively listening to their conversations and watching them play and you may feel invigorated when discussing with co-workers about your observations of the kids. I find it particularly fascinating when STEM activities are involved because it gives me an opportunity to reflect on something different.

Poh: What are some of realizations you've come to as an early childhood educator?

Jade: For me as an educator, I've thought of how I've come full circle when I first started ECE and how I see things now nine years later. My own personal development is that the way to make things change is to take the initiative. I was so empowered and moved by this way of guiding children that I was excited to share my discoveries with others in different fields from me in the beginning. The knowledge I gained from hearing other's perspectives helped me influence what I know to be true and create a mark in their world. I feel I have contributed in some way that has affected me and others around me. This is part of the movement that pushes me everyday as my career is what I breathe and live with not only in my work but personal life as well. Together, the reward is the journey we walk but diverge into many pathways that start from one point.

Poh: What is the one thing you would want the readers to take away from this interview?

Jade: In the end, I want other educators to know we all struggle in the many points in our life where we feel stuck, unable to change or find things repetitive. It is okay to live in that space but don't feel discouraged when you have those pauses in your work or professional life. Acknowledge who you are in those moments and reflect on what is needed for you to get out of that mindset so you can response appropriately and make changes. Change is possible but only if you take the initiative to try something new, take risks, be vulnerable but most of all, be authentic by being yourself. Be honest with yourself and true with how you feel when those moments happen. Don't be afraid to share your doubts and struggles with fellow workers because more than not, they had them too which makes things all that more relational in any context. And most of all, seek support from other educators, communities, and even researchers, like what I have with you, Poh!

Poh: Thank you Jade for sharing all that you've learned throughout the years and your willingness to be open and relate to the reader about how you've searched for ways to further develop and relate to bringing science to your students.

Biography

Poh Tan is currently completing her second PhD in Education from Simon Fraser University where her thesis focuses on decentering dominant ways of teaching and learning science, specifically through an Indigenous Hawaiian framework and storytelling. Her first PhD was obtained from the Faculty of Medicine at the University of British Columbia, where she focused on the biology of blood stem cells. She is a research fellow at Science World and Vancouver Botanical Gardens Association, Vancouver's science museum and urban garden. She is founder and CEO of STEMedge Inc., a STEM educational consulting company. Poh has been practicing STEM outreach with K-12 students in the community space for over 20 years and frequently trains science facilitators who bring STEM to the public.

Jade Leong's journey in early childhood education began with a genuine passion for nurturing young minds. After high school, she embarked on a career path filled with purpose. Encouraged by her mother's observation of her caring nature, Jade explored her calling. Her fascination with children, especially those younger than her, grew during elementary school. The pivotal moment came when Jade attended an adult continuing studies information session at a community center. There, she realized the profound importance of the early years in a child's development. What captivated her most was the unique bond early childhood educators formed with children, moving beyond mere rote learning. This revelation marked the beginning of a new chapter in Jade's life. For the past eight years, she has dedicated herself to the field of Early Childhood Education. Jade's commitment extends to specialized training and hands-on experience in supporting children with special needs and fostering inclusive practices. She continues to shape young lives with her caring nature and unwavering dedication.

References

Brenneman, K. L. (2019). Integrating STEM into Preschool Education; Designing a Professional Development Model in Diverse Settings. *Early Childhood Educ J, 47*, 15–28. doi:https://doi.org/10.1007/s10643-018-0912-z

Brenneman, K. S.-B. (2009). Early mathematics and science: Preschool policy and practice. *Preschool Policy Brief,*.

Buechel, C. (2021). An Investigation of the Effects of Self-Efficacy on STEM Implementation. *Curriculum and Instruction Undergraduate Honors Theses*. Retrieved from https://scholarworks.uark.edu/cieduht/24

Greenfield, D. J. (2009). Science in the preschool classroom: A programmatic research agenda to improve science readiness. *arly Education & Development, 20*, 238–264.

Katzenmeyer, C., & Lawrenz, F. (2006). National science foundation perspectives on the nature of STEM program evaluation. *New Directions for Evaluation*(109), 7-18.

Smith, K., Douglas, T., & Cox, M. (2009). Supportive teaching and learning strategies in STEM education. *New Directions for Teaching and Learning.*, 19-32. doi:10.1002/tl.341

Tan, P., & Leong, J. (2021). Teacher and researcher in entangledrRelations. *SFU Educational Review, 14*(1), 67 - 787. Retrieved from https://journals.lib.sfu.ca/index.php/sfuer/article/view/2405

SCIENTIFIC DISSEMINATION PRACTICES IN BASIC EDUCATION: REFLECTIONS ON A BRAZILIAN EXPERIENCE IN A PUBLIC TECHNICAL SCHOOL

DAIANA CAMPANI
Unisinos University

Abstract

This work assumes that it is a basic school commitment to contribute to scientific dissemination, scientific literacy, and the establishment of a culture of science in society, especially in Brazil, a country where scientific denialism is still very present. The purpose of this text is to reflect on the challenges and results of a practical experience with scientific dissemination at the Fundação Escola Técnica Liberato Salzano Vieira da Cunha, a public technical high school in Novo Hamburgo, Rio Grande do Sul, Brazil. Two actions carried out by a Portuguese language teacher at the institution are reported: the work with the discursive genre news for scientific dissemination in high school classes and the editorial of the journal Liberato Científica, the institution's journal for scientific dissemination.

Keywords: Scientific dissemination, Scientific literacy, Portuguese language, Basic education.

Introduction

This text results from researchers' reflections on the experience of scientific dissemination (SD) work in Brazilian public basic education. I have been a Portuguese language teacher in the city of Novo Hamburgo, state of Rio Grande do Sul, Brazil, for over twenty years. During this journey, I realized the need to discuss with students' themes such as the scientific dissemination, scientific literacy, and scientific culture. In our country, during the COVID-19 pandemic, we faced a reality of strong scientific denialism, misinformation, and infodemic, motivated by many factors including the attitude of the Federal Government at the time. However, these were not phenomena that emerged with the COVID-19 health crisis. (Castelfranchi, 2021; Massarani et al., 2020). According to Pasternak and Orsi (2021), the rejection of vaccines, for example, is as old as vaccination itself. There have also been movements of flat-earthers, creationists, and global warming deniers for a long time (Pasternak & Orsi, 2021).

Even before the pandemic, the survey "What Young Brazilians think about Science and Technology" (Massarani et al., 2019) brought results that caught my attention considering the range of Brazilians between 15 and 24 years old, precisely the age range of students I work with at the high school level. A total of 2206 young people living in all regions of Brazil were interviewed. According to these data, most young people showed a greater interest in science and technology than in sports and religion. These young people realize the importance of the topic, strongly support science, and believe that scientists are among the most reliable sources of information. They have, in general, a positive image of scientists and believe that investment in the area should be increased. However, most were unable to mention the name of a research institution (even some studying at universities), or a scientist, corroborating the data from the survey extended to other age groups.

Access to scientific and technological information was pointed out as low, and the means of access that stand out are Google, YouTube, Whatsapp, and Facebook, which — a factor also pointed out in the research — are means of disseminating misinformation. The interviewees also stated that they had difficulties in checking whether a piece of news about S&T is false. Basic information about science is also unknown to many, such as that antibiotics do not fight viruses (60% of respondents). Other issues of concern were the drop in visitation to science museums (only 6% had visited) and the expression of doubts about social and political controversies that permeate science, such as vaccination, climate change, and evolution. Furthermore, it is essential to highlight the stereotyped image that young people still have of scientists. Positive images stood out when characteristics such as creativity, organization, and ability to learn were pointed out. However, statements such as "they are weird", "they are not very attractive", "they do not have a happy marriage", "they have few friends" still appeared.

Data such as these indicate the need for basic education to contribute to discussions on science and society. This concern is supported by the Base Nacional Comum Curricular (BNCC) itself (Brasil, 2017). According to this guiding document, scientific literacy needs to be developed in primary school. Proposing the centrality of the text as a unit of work in the Portuguese language class, the BNCC guides the inclusion of genres belonging to certain fields of action, among which are listed the "field of study and research practices" and the "journalistic field-media", in an intrinsic relationship with science and its dissemination.

In 2011 I began a teaching career at the Fundação Escola Técnica Liberato Salzano Vieira da Cunha, a high school public technical school in Rio Grande do Sul with a tradition of teaching through research and scientific dissemination (Fernandes et al., 2017; Müller, 2018). In this space, I began to question myself more strongly about the need to work with reading and production of SD texts in the classroom. I intended to contribute so that the results and — perhaps more important than that — the path of these students' research could also reach citizens who were not specialists in science.

Based on this concern, I came into contact with the work of the CCELD group — Communication in Science: Linguistic and Techno-discursive Studies, coordinated by Professor Maria Eduarda Giering, from the Graduate Program in Applied Linguistics at Unisinos University, Rio Grande do Sul, Brazil. After reading some papers and contacting the group's researchers, I began to develop pedagogical proposals that included SD texts in Portuguese Language classes.

In 2020, the COVID-19 pandemic began, and with that, my concern about information clutter became even stronger. I then joined the CCELD group as a doctoral student, and studies in Applied Linguistics made it possible to qualify this work. The same year, I also assumed the position of editor of the Liberato Foundation's SD journal, Liberato Científica, a publication that presents, to a wide audience, the work of young researchers in basic education who participate in the largest science fair in Latin America promoted by the International Exhibition of Science and Technology (*Mostratec*).

This text aims to socialize two actions that I carry out at school. Reflecting on the challenges and the fruits, practices that aim to contribute to the culture of science, scientific literacy and scientific dissemination in society, the work with reading and writing of texts belonging to the discursive genre news of scientific dissemination in the 1st years of high school and the editorship of *Liberato Científica* journal, the school's scientific dissemination journal.

Starting points: some important concepts

SD is understood, in this text, as a recontextualization of scientific knowledge, with the aim of making science content accessible to a wide audience. It differs, therefore, from the dissemination of science, which is related to the process of communication with peers, in technical and formal language (Bueno, 1985; Zamboni, 2001). SD is not understood here as a

simplification or a translation of scientific discourse to a "lay" public. Therefore, it is part of a broader context of public education, bringing science closer to people's daily lives.

Scientific dissemination is an important step towards the promotion of scientific literacy and the culture of science in Brazil. Cunha (2017) and Santos (2007), when discussing the concept of scientific literacy, show that, just as it is not enough to know how to read and write and not use reading and writing socially, science is no different. It is not enough for citizens to just "read" information about science; they need to know how to use this information socially, to know how to debate the subject at least, base their decisions on this knowledge and even how to recognize the cultural value of science.

Vogt (2003) presents the concept of scientific culture, as he believes that the process that involves scientific development is cultural, whether from the point of view of its production and dissemination among peers, its circulation in teaching or, even, its circulation in society at large. The author presents a model of the development process of scientific culture represented in the form of a spiral:

For the author, in the first quadrant of the *production and dissemination of science*, scientists are the addressees and recipients of science; in the second, *the teaching of science and the training of scientists*, scientists and teachers provide information for students of all levels; in the third, from *teaching to science*, scientists, professors and museum directors provide information for students and a young audience; finally, in the fourth, the *scientific dissemination*, journalists and scientists provide information for society in general.

According to the author, the Elementary and High education systems would be in the second quadrant; science fairs, on the third; and science journals and newspapers, in the fourth. It is also interesting to highlight the role of feedback in this spiral, since all quadrants are interrelated. At a time when society is questioning scientific knowledge, it is possible to ask: in which quadrant is this spiral breaking?

The two experiences narrated here are based on the assumption that it is the primary school's role to provide opportunities for discussion on the subject and on the role of language in this task. According to Nunes (2019),

> Science communication plays an important role, as it provides the general public with contact with scientific discoveries; it also enables democratic practice, as it highlights specialized approaches, in order to provoke possible discussions in the reader. This is how society is transformed: when science experiments and discoveries reach the non-specialized public, in an active and participative way. (p. 14).

The classroom experience

Teaching through research is already adopted in many Brazilian basic education schools, a proposal that has gained support with the publication of the Base Nacional Comum Curricular (Brasil, 2017), which mentions the concept of "scientific literacy" and presents in the area of Languages and its Technologies the "field of study and research practices" as one of the priority fields of social action. In the BNCC (Brasil, 2017), the concept of scientific literacy appears directly in the area of Natural Sciences defined as

> […] the ability to understand and interpret the world (natural, social, and technological), but also to transform it based on the theoretical and procedural contributions of science. In other words, apprehending science is not the ultimate purpose of literacy, but the development of the ability to act in and on the world, which is important for the full exercise of citizenship. (p. 321).

In the Languages/Portuguese area, BNCC suggests a work with texts/discourses "that circulate both in the school sphere and in the academic and research spheres, as well as in scientific dissemination journalism" (Brasil, 2017, p. 480).

The Technical School Técnica Liberato Salzano Vieira da Cunha is a public institution linked to the Government of the State of Rio Grande do Sul. It began its activities in 1967, with the Technical Course in Chemistry. Currently, it has more than three thousand students enrolled. In addition to evening courses following high school, the course offers four-day courses integrated into this level of education: Chemistry, Electronics, Mechanics, and Electrotechnics. Such courses, aimed at students completing Elementary School, last for four years, plus 720 hours of Supervised Internship (Fundação Escola Técnica Liberato Salzano Vieira da Cunha, 2023).

Whether through the work proposals of the different disciplines that make up the curriculum of the technical courses, or through its internal and external science fairs, the school is a reference in the region when it comes to scientific method in basic education. Every year this school holds an international science fair- the International Exhibition of Science and Technology (Mostratec) that welcomes young researchers from basic education. Although the school is a high school, twelve years ago it expanded this fair, in a junior version, to also receive elementary school students from all over Brazil, and, more recently, even kindergarten students.

As a Course Conclusion Work, many of the Institution's students carry out research, configuring a scientific initiation work in High School. Therefore, with this proposal, the opportunity for this school to contribute not only to the dissemination but also to scientific dissemination is undeniable. SD's objective is not to make the target audience an expert on that subject, but rather to allow it to "better understand the phenomena of the world" in order to be able to "debate them when they present problems of a moral nature" (Charaudeau, 2016, p. 550).

Since joining the school, I started to watch students' presentations at Mostratec or even participate in evaluation boards of these works. I realized, however, a point to be discussed: many of these young scientists did not care about - or perhaps were unable to - recontextualize their language so that a reader who was not a specialist in the technical area - as was my case, a professor in the area of Languages - could understand. I then started to think about contributing to this challenge and, for some years now, I have been developing, with the 1st year classes of the Chemistry and Electronics courses, a pedagogical proposal with the discursive genre of news of scientific dissemination based on the choice of a research project presented at this school's science fair. This news produced by the students should have primary school children in the region as its target audience.

It is evident, here, that the practice is one of school journalism; in this case, produced by high school student-researchers with primary school interlocutors in mind. This proposal started from a conception of learning and language as interaction — interaction between teacher and student, between colleagues, between high school and elementary school students or early childhood education and the social environment. Such conception is based on the ideas of Bakhtin (2003) and therefore takes the concept of discursive genre as the basis for all didactic decisions.

The objective is to discuss the role of science and SD in a democratic society and the fact that students, as young scientists, will need to be concerned with the language used to interact with other scientists, as well as with the non-expert. I tried to emphasize the importance of the social practice in which they were inserted to produce the text that was the final product.

The work is the result of an experience that corroborates the thesis that scientific research carried out with the social commitment of Applied Linguistics, within the scope of graduate programs, can effectively reach the basic education classroom, bringing important results for the society. The pedagogical proposal described here is anchored in works by the CCELD group, such as Giering and Souza (2013), and Nunes (2019).

Giering and Souza (2013) address the concept of scientific media dissemination, pointing out that it is located at the intersection of three discourses: the scientific, the didactic, and the media. For the authors, this discourse has a double purpose: to inform the reader (making-knowing) and, at the same time, to capture their interest (making-feeling). It is important to point out that in the pedagogical proposal to be discussed in this article, the discourse was not restricted to the didactic or the scientific, so that students could effectively assume the role of scientific disseminators as “journalists for a day”, creating texts that were disseminated in the media going beyond the walls of the school.

Since, in this didactic proposal, the selected interlocutor is the child and youth reader, the use of SD studies for children was relevant. For Giering and Souza (2013), an SD text aimed at children is intended for a reader who is in the process of intellectual formation and may not necessarily be interested in scientific topics. Among the strategies to achieve making-knowing and making-feeling, the authors appeal to the allocutive modality of interpellation (use of the pronoun "you"); use of verbs in the imperative mood, interrogative or exclamatory sentences and emotive evaluations of an object, being or action; references to themes and situations supposedly known to the reader; anticipation of possible questions or evaluations by the reader and calling attention to the fact that this young reader has learned something new.

Nunes' work (2019) is also dedicated to SD aimed at children. The researcher sought to identify linguistic-discursive and iconic elements of patemization in texts. Patemization is defined as "a strategy — which aims to capture and seduce the reader — used by the speaker, who mobilizes a set of discursive categories to organize an interaction through affection" (Nunes, 2019, p. 13). The work presents data that show that childhood is the phase in which science is most distant, hence the importance of discussion on the subject. Some of the pathetic strategies cited by the researcher, in addition to those already mentioned by Giering and Souza (2013), are the following: explosive opening of the text (beginning in the form of a question), interjections, words found in children's stories, situations that arouse disgust, humor, unusual facts, playfulness, relationship with the child's daily life, anthropomorphization of nature, use of the child's own language, among other strategies.

In the news of scientific media dissemination, there are, as well as in other news: title, subtitle (optional), lead (succinct information on the reported journalistic fact and the main circumstances in which it occurs), detailing, intertitle (optional), usually accompanied by some iconic element (illustration, photo, graphic, infographic, caption) – and, at the same time, the organization of the academic article – abstract, introduction, materials and methods, results, and discussion of results (Giering, 2013).

The text needs to address the final or partial results of a scientific activity relevant to the community. The answers to the six fundamental questions, popularly known as the "3Q+COP formula", which must be answered in the text are related to this scientific novelty: who were the scientists, who discovered what, where, when, with what justification (why), with what methodology (how), but without the depth of a report.

The language needs to be simple, objective, and clear, seeking strategies to inform and, at the same time, capture the reader's attention. All scientific concepts must be explained. For this, it presents definitions, bets, comparisons, or analogies, being a different text from scientific articles produced for specialized scientific journals or from reports produced for science fairs, in which the author writes from scientist to scientist. The author needs to write for readers unfamiliar with the research topic or even with science. Another striking feature of the scientific dissemination news is the use of citations, a resource through which the journalist brings the

voice of the scientist responsible for the research or someone who is directly or indirectly linked to it (Giering, 2013).

According to the review of Nunes's ideas (2019), in the case of the young reader, the journalist can use pathetic strategies to achieve the double objective. It is a text, if written by the journalist, in third person. However, unlike non-scientific news, SD's text can use evaluative or qualifying expressions, according to the author's notes. It is a text published in journals, magazines, or blogs with popular access.

Every year, the pedagogical actions are designed specifically for the classes involved, considering their characteristics and the survey of prior knowledge carried out throughout the school year. However, the table below summarizes some actions that have been repeated over these years, since 2019:

Table 1. Some Stages of the Pedagogical Proposal

Steps prior to Mostratec
1. Study of the genre's "chronicle" and "news", based on an articulation between chronicles from the book *Imaginário Cotidiano*, by Moacyr Scliar (2001), and news that originated the texts of that author.
2. SD news study for young people and adults and for children. Sub-steps: • Reading scientific news published on scientific dissemination sites a few days before class. Exercises involving the text and the characteristics of the genre. Discussion about science in society, fake news, and the SD news. Explanation of the proposal to be developed. • Reading and discussion of children's SD news texts. Discussion on children's SD news, the characteristics of the news genre for children and the differences between the news and the article for children in the sphere of journalism in SD. Analysis of SD news texts for children selected by the teacher, published a few days before classes. • Task in groups: division of pathemic strategies listed by Nunes (2019) for presentation to colleagues, through examples found in the texts read. • Division of groups for interviews at the fair. • Discussion about the journalist's attitude and tips on how to be a "journalist for a day".
Heading to Mostratec (always in October)

Steps after Mostratec
1. Text production • Socialization, in the classroom, about the results found in interviews with elementary school scientists. Discussion about the language of popularization of science found (or not) in the works presented in the high school exhibition, also visited by the students. Evaluation of the validity of the task by the students. • Production and delivery of news. • Reading of the news by colleagues from other groups, with completion of the evaluation form and suggestions. • Reading, by the teacher, of the original texts and evaluation sheets with suggestions from colleagues. Return to students through tickets. No grade was assigned to this step. • Rewritten by the students. • New evaluation by the teacher and attribution of grade. Oral and written feedback from the teacher to students. 2. Referrals for publication.

Note. Author's table.

One of the last stages of the proposal was the revision of the texts. At that moment, each group should read the text of their colleagues and point out, if applicable, suggestions to improve the news, based on an evaluation form, reproduced below:

Table 2. Evaluation Form

ELEMENTS	**CONTRIBUTIONS**
1. Cover	
2. Title and subtitle	
3. Lide and news body	
a) 3Q+COP	
b) Use of science-specific vocabulary with explanations of these terms for a non-specialist audience	
4. Strategies for attracting the child's interest	
a) Explosive opening	

b) Use of interjections	
c) Evaluative and qualifying expressions (Ex. extremely important, amazing environment etc.)	
d) Words and expressions found in children's stories	
e) Situations that arouse disgust or embarrassment/disasters	
f) Humor	
g) Fantasies/characters they identify with	
h) Victories in adversity/good overcomes evil	
i) Unusual facts/fascinating discoveries/surprises	
j) Lucidity (playing with words, expressions, images)	
k) Aspects experienced by the child/events of the child's universe	
l) References to the interlocutor (use of the pronoun “you”, imperative verbs)	

m) Use of interrogative sentences or exclamatory sentences	
n) Anticipations of possible questions or evaluations by the young reader	
o) Drawing attention to the fact that the young reader learned something new (Appreciation of scientific knowledge)	
p) Anthropomorphization of elements of nature	
q) Use of language close to the child's daily life/lexicon	
5. Photo (with the presence of all the members of the group) and **caption**	
6. Presentation/Formatting	
7. Grammar review	

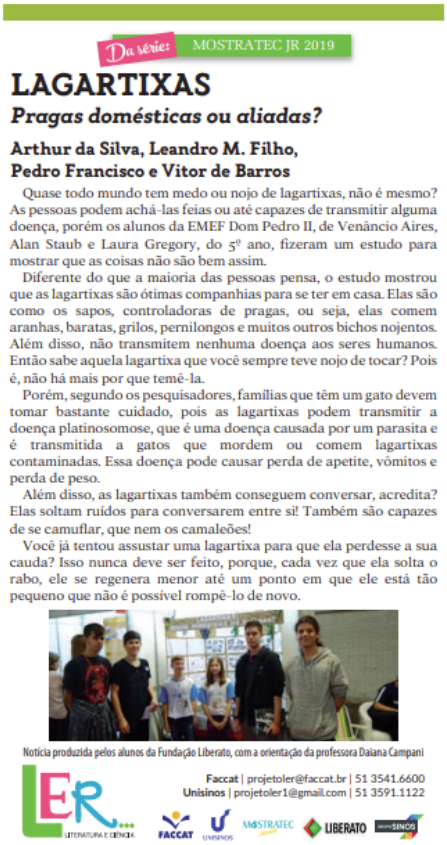
Note. Author's table, based on Nunes (2019).

As a stage of publicizing the final product, some of the texts produced always go beyond the walls of the institution. Texts have already been published in the largest newspaper in the city, on the fair's social networks and in the school's journal *Expressão Digital*. Thus, the interlocutor of the text is not just the teacher of the Portuguese Language discipline, who proposed the work, but also children from Elementary School in the region, who will be able to get in touch with the scientific knowledge produced by young scientists and have ideas for their research work. In the same way, the authors of the surveys themselves can see their work become news produced by "journalists" from Technical High School. Elementary school teachers can also work with authentic texts especially aimed at their students. In addition, every community can have access to these texts. Some examples of publications follow.

Figure 1. *Instagram Page of Mostratec Júnior*

Note. Author's photograph available in: https://www.instagram.com/p/CERvLe6pPM9/. Accessed on: 10 Aug. 2023.

Figure 2. *Jornal NH*



Note. Photo Credit: Jornal NH (2019).

Figure 3. *Journal Expressão Digital*

Note. Photo Credit: screenshot of the author's computer, from the website https://expressaodigital.liberato.com.br/?p=13946. Accessed on: 10 Aug. 2023.

It is evident that not all texts meet all the requirements expected by the genre. In many cases, it is still possible to observe a mixture of communication language with scientific dissemination, following, for example, the norms of the Associação Brasileira de Normas Técnicas - ABNT, for academic articles. Another point to be rethought concerns the suggestions made by the groups in the colleagues' files, with corrections of supposed “errors”, often grammatical, which did not exist. The teacher's role was to signal that the group should ignore that suggestion.

Despite the challenges of the proposal and the constant rethinking of practices, intrinsic to any pedagogical action, the objective of discussing the role of science and SD in a democratic society was achieved. This was an opportunity to initiate this discussion with these students, a debate that needs to be continually expanded in future proposals.

The editorial board of *Liberato Científica* journal

Liberato Científica journal, published since 2015, is one of the actions of the Liberato Foundation that reinforce the institution's commitment to scientific dissemination. It is only when the results of scientific research reach society as a whole and does not only circulate among specialists, but we can also effectively speak of a democratic society. It is the Institution's responsibility, in addition to stimulating research in its actions, to ensure that the results are socialized - and socialized not in a hierarchical way, but in a dialogic way. The Foundation believes that, when science establishes a dialogue with society as a whole, the population can make decisions based on this knowledge - and not on fake news or pseudo-arguments.

With this publication, the Liberato Foundation wants to help the community realize that the results of scientific research are at our side, in our daily lives. The researchers of the articles that make up the journal were all participants of the Mostratec or of the Junior Mostratec the year before publication and are faced with a great challenge: to elaborate a text that is not a scientific paper (an academic text, which is intended for specialists). They did need to prepare an article for scientific dissemination, that is, a text that is committed to the popularization of science. How to explain, for example, what a peptide is to someone who is not an expert in chemistry? How to discuss literacy with someone who is not a linguistic specialist?

For this purpose, these authors make use of language resources such as comparisons, analogies, interactions with the reader and even a certain dose of humor in some cases. They thus took on a dual role: making and disseminating science which is also a scientist's commitment.

Since 2020, I have been in charge of the publication's editorial. During the Mostratec, which always takes place in October, works are chosen that could be published in the following year, observing different areas of knowledge that receive the *Liberato Científica Award*. My role is to get in touch with these authors, explain the SD strategies to them, monitor the process of preparing the texts, forward them to the Scientific Committee and carry out the linguistic revision.

The figures below show some of these articles:

Figure 4. *Journal Liberato Científica*

HEVS: TECNOLOGIA NA PRESSÃO ARTERIAL

UMA ABORDAGEM PARA TRAZER DINAMISMO À SAÚDE NO BRASIL

HEVS – Hypertension Estimation Visual System

Marcos Augusto Flôres e Vladimir Simões da Luz Júnior
Curso Técnico de Eletrônica, Fundação Liberato, Novo Hamburgo – RS, Brasil
Orientador: Marco César Sauer

Nós poderíamos dizer que o impulso inicial para a criação do projeto foi a paixão pela ciência, a sede pelo conhecimento ou a promoção de uma mudança significativa no mundo. Entretanto, a inspiração revela-se mais simples: inovar. Seria injusto não mencionar também o anseio de participar das feiras.

Começamos nossa jornada ainda em 2019, na Feicit – Feira Interna de Ciência e Tecnologia, da Fundação Liberato. Na ocasião, queríamos otimizar os cruzamentos da cidade construindo semáforos inteligentes. Essa proposta não seguiu como esperávamos; contudo, serviu de fagulha para a criação do projeto sobre o qual estamos escrevendo. Em 2020, durante a pandemia, avaliamos que projetos na área da saúde seriam um grande foco para as próximas feiras. Soluções para evitar catástrofes na saúde foram questões a que a sociedade atentou. A partir disso, começamos nossas conversas com nosso professor orientador, Marco Sauer, a quem é devida uma importante parte desse trabalho.

Depois de nos chocarmos com os dados da mortalidade das doenças cardiovasculares – a média de mortes de um ano "normal" supera em 7 vezes a média obituária da covid-19 em maio de 2020, no Brasil, conforme dados da BBC News – decidimos levar nossos esforços para essa área, a cardíaca. Aí vem um ponto que consideramos importante ressaltar: a criação de ideias também deve ser estratégica. É um erro comum esperarmos o tempo passar para "ter uma ideia". Isso não acontece. Imagine a seguinte situação: Alberto Santos Dumont, no começo do século XX, era um homem comum, com uma vida normal. Tinha seus interesses, é claro, mas não era um ávido alimentador de suas paixões. Entretanto, em uma regular terça-feira de sol, Santos Dumont, ao se olhar no espelho, "teve uma ideia" e disse a si mesmo: "Criarei um aeroplano unido a um balão 14 para reduzir o peso efetivo facilitando a decolagem, instalarei um motor náutico Antoinette de 50 cavalos-vapor, envernizarei a seda das asas, retirarei a roda traseira, cortarei a estrutura portadora da hélice e voarei no 14-bis!" Isso é completamente inimaginável! Somente o assíduo contato com o conhecimento e o afinco na ciência farão as ideias surgirem. As ideias são construídas, não tidas.

Note. Source: Liberato Científica Journal (2022).

Figure 5. *Journal Liberato Científica*

MENOS ERVAS DANINHAS E MENOS IMPACTOS AO MEIO AMBIENTE

João Lucas Hansen e Júlia Schmitt
Curso Técnico de Química, Fundação Liberato, Novo Hamburgo – RS, Brasil
Orientadora: Schirlei Viviane Rossa

Entenda por que o estudo comparativo aponta o ácido acético como um promissor substituto para agrotóxicos comerciais em culturas de tomate-cereja.

Que os agrotóxicos acarretam diversos riscos tanto para a saúde dos seres humanos como para o meio ambiente não é novidade. Segundo relatório da ONU de 2017, anualmente morrem cerca de 200 mil pessoas de envenenamento agudo por pesticidas no mundo. No Brasil, um fato agravante é a utilização de agrotóxicos em quantidades acima das recomendadas com baixa fiscalização. Foi pensando nisso que começamos a pesquisar mais sobre o tema para entender suas causas e consequências e aprender a como lidar com elas.

O resultado dessa investigação nos levou a pensar na utilização de algum substituto menos prejudicial a algum agrotóxico usado comercialmente no Brasil. Contudo, o tema ainda estava muito amplo; precisávamos focar melhor em alguma cultura afetada por um agrotóxico que fosse danoso ao meio ambiente e à saúde. Voltamos então a aprofundar nosso estudo e a conversar com especialistas da área e definimos como cultura estudada o tomateiro, não só pelo tomate ser um produto muito consumido mundialmente como também por absorver bem agrotóxicos utilizados em suas plantações.

O tomate-cereja foi a variação escolhida por sua plantação ter menor porte e possuir um ciclo de vida mais curto, o que facilitou o desenvolvimento do projeto dentro do ano de 2021. Já quanto ao agrotóxico a ser estudado, acabamos optando por trabalhar com o metribuzin, por ser o herbicida mais utilizado na cultura de tomate-cereja mundialmente, ser tóxico a células do fígado de fetos animais, ter efeitos sobre enzimas do fígado, modificar o sistema hormonal e poder acarretar fitotoxicidade (capacidade de causar danos na parte aérea da planta).

Logo de início, pensamos que seria muito interessante estudar como fazer essa substituição com algo que já fosse usado na cultura popular, um tipo de "remédio caseiro" contra as ervas daninhas. Foi pensando nisso e sabendo que o vinagre, ou ácido acético, é comumente utilizado como um herbicida caseiro, que decidimos testar como diferentes concentrações do ácido agiriam frente a plantas invasoras mais comuns na cultura de tomate-cereja e, ainda, comparar sua eficácia e seus danos frente ao metribuzin.

Ao nos aprofundarmos mais no referencial teórico, encontramos artigos explicando que o ácido acético atua como um herbicida de contato, isto é, ele ataca e mata as plantas por meio da destruição das membranas da célula, causando, assim, a rápida dessecação de tecidos vegetais. Além disso, o ácido ainda se torna biodegradável quando liberado na água ou no solo, uma vez que é rapidamente degradado por microorganismos.

Tendo as bases bem definidas, montamos nossa metodologia do projeto, feita a partir do preparo de soluções com diferentes concentrações de ácido acético, 6%, 12%, 18% e 24% em volume. Realizamos o estudo com foco em dois casos diferentes.

O primeiro caso foi o estudo do ácido como herbicida em pré-transplantio, ou seja, a aplicação de herbicida antes de inserir as mudas de tomate no solo de cultivo. Em oito vasos, semeamos ervas daninhas das espécies dinheirinho (*Pilea Microphylla*W), quebra-pedra (*Phyllanthus tenellus*) e picão-preto (*Bidens pilosa*), que foram escolhidas por serem as que mais afetam as plantações de

Note. Source: Liberato Científica Journal (2022).

This process is not always without challenges. Perhaps the biggest one is precisely that the authors and the school community understand the differences between the dissemination of science (between peers) and scientific dissemination (to a wide non-specialized public). Sometimes, I still receive texts with language that is very much geared towards other scientists, without the perception that that vocabulary, which is quite common in the area of authors, is completely unknown by the non-specialist. Likewise, it is sometimes difficult for authors to popularize their research without "childishizing" the language or making it informal. Thus, a constant process of writing and rewriting by the authors, evaluation, and reassessment by the editorial committee, is necessary. I notice however that each year a new publication is launched, and more and more texts from the following years are more suited to the expected genre.

Final considerations

With the report of these two actions, I reinforce the social commitment to Applied Linguistics, the area in which I am carrying out my research. I believe that actions taken in high school can contribute to changing the scenario of denialism, misinformation, and infodemic that have always existed but have been accentuated during the pandemic, especially in Brazil. Studying scientific dissemination texts, starting from the theoretical-methodological support of research by linguists can be an important step towards the establishment of a culture of science in our country. I also emphasize the importance of the partnership between university and basic school, since it was based on research by the CCELD group so that the work could be carried out and qualified.

References

Bakhtin, M. (2003). *Estética da criação verbal*. São Paulo: Martins Fontes.

Brasil. Ministério da Educação. (2017). *Base Nacional Comum Curricular*. Brasília: MEC.

Bueno, W. C. (1985). Jornalismo científico: conceitos e funções. *Ciência e Cultura*, *37*(9), 1420-1427. https://biopibid.paginas.ufsc.br/files/2013/12/Jornalismo-cient%C3%ADfico-conceito-e-fun%C3%A7%C3%A3o.pdf.

Castelfranchi, Y. [TV Valongo]. (2021, July 6). *Divulgação científica na contramão: novos modelos de divulgação científica para tempos de crise* [Video]. You Tube. https://www.youtube.com/watch?v=GHE5P56h_3A. Acesso em: 7 maio 2022.

Charaudeau, P. (2016). Sobre o discurso midiático e sua midiatização. *Calidoscópio*, *14*(3), 550-556.

Cunha, R. (2017). Alfabetização científica ou letramento científico?: interesses envolvidos nas interpretações da noção de scientific literacy. *Revista Brasileira de Educação*, *22* (68), 169-186. http://educa.fcc.org.br/pdf/rbedu/v22n68/1413-2478-rbedu-22-68-0169.pdf.

Fernandes, A. I., Beltrame, C. M. R. B. B., Silva, D. M., Souza, J. E., Filimberti, M., Zulke, M. I. U. & Pacheco, R. (2017). *Liberato — 50 anos*. Histórias de uma trajetória. Fundação Liberato.

Fundação Escola Técnica Liberato Salzano Vieira da Cunha. (2023). Sobre a Liberato. https://www.liberato.com.br/sobre-a-liberato/.

Giering, M. E. (2013). Gêneros acadêmicos e de divulgação científica. In C. P. Damin & M. E. Giering (Eds.), *Leitura e produção de textos de comunicação da ciência*. São Leopoldo: Unisinos.

Giering, M.E. & Souza, J.A.S. (2013). Informar e captar: objetos de discurso em artigos de

divulgação científica para crianças. In M. M. Cavalcante, C. M. C. Lima &

S. C. Marquesi (Eds.), *Referenciação: teoria e prática*. Cortez.

Massarani, L., Waltz, I. & Leal, T. (2020). A COVID-19 no Brasil: uma análise sobre o consumo de informação em redes sociais. *Journal of Science Comunication*, *19* (7). https://jcom.sissa.it/sites/default/files/documents/JCOM_1907_2020_A07_pt.pdf.

Massarani, L., Castelfranchi, Y., Fagundes, V., Moreira, I. & Mendes, I. (2019). *O que os jovens brasileiros pensam da ciência e da tecnologia*. Resumo Executivo. Fiocruz/INCT-CPCT.

Müller, D. M. (2018). *Das feiras de ciências à iniciação científica no ensino médio profissionalizante: história da Fundação Escola Técnica Liberato Salzano Vieira da Cunha (1974-2009)*. [Tese de Doutorado. Programa de Pós-Graduação em Educação, Unisinos].

Nunes, D. S (2019). *Estratégias patêmicas em artigos de popularização da ciência para crianças no domínio midiático digital*. [Dissertação de Mestrado. Programa de Pós-Graduação em Linguística Aplicada, Unisinos].

Pasternak, N., Orsi, C. (2021). *Contra a realidade: a negação da ciência, suas causas e consequências*. Campinas: Papirus 7 Mares.

Santos, W. L. P. (2007). Educação científica na perspectiva de letramento como prática social: funções, princípios e desafios. *Revista Brasileira de Educação*, *12* (36) http://www.scielo.br/j/rbedu/a/C58ZMt5JwnNGr5dMkrDDPTN/?format=pdf&lang=pt.

Scliar, M. (2011). *Imaginário cotidiano*. Global Editora.

Silva, J. Z. (2020). *Contribuições dos estudos de letramento científico para as práticas de pesquisa na educação básica*. [Dissertação de Mestrado. Programa de Pós-Graduação em Letras, UFRGS.].

Vogt, C. (2003). A espiral da cultura científica. *Comciência.* http://www.comciencia.br/dossies-1-72/reportagens/cultura/cultura01.shtml.

Zamboni, L. M. S. (2001). *Cientistas, jornalistas e a divulgação científica: subjetividade e heterogeneidade no discurso de divulgação científica*. São Paulo: Autores Associados.

ARTISTIC AND CREATIVE EXPRESSIONS

DECODING

DANIEL B. ASEL
Association of Registered Graphic Designers

Abstract

In this submission, I emphasize the importance of understanding neurodiversity, particularly in early education, drawing from my experience with dyslexia. My goal is to foster empathy towards neurodivergent individuals, countering stereotypes associated with people like me. My creative piece, "Decoding," metaphorically represents the dyslexic experience, in which neurodivergent individuals who have dyslexia may struggle with the daily decoding of information within their cognitive load. I introduce Dyslexia Canada's "itshardtoread.org" as a crucial resource for offering insights into the dyslexic experience. This platform adheres to accessibility standards, facilitating empathy cultivation. I advocate for holistic and inclusive learning environments, and argue for recognizing dyslexics as creative, empathetic, and adept problem solvers who face preventable mental health challenges if recognized early enough. Inspired by Indigenous ways of knowing, I highlight the importance of "seeing the spirit" of learners, contrasting with Western compartmentalization. This approach can boost self-esteem and self-worth among neurodivergent individuals. In conclusion, I stress the urgent need for empathy in education, proposing two actionable recommendations: exploring empathy through storytelling, adherence to legal accessible design standards outlined by The Association of Registered Graphic Designers, and how digital solutions in design for the classroom can positively impact neurodivergent learners. The overarching goal is to promote comprehensive understanding and appreciation of neurodivergent individuals. My submission concludes with a curated list of resources for further exploration in this vital area.

Keywords: neurodiversity, dyslexia, empathy, accessibility, Indigenous knowledge, cognitive load, inclusive education, storytelling, accessible design.

Figure 1. *Title:* Decoding

Note: Illustration by Daniel Asel, RGD, who also operates under the artist pseudonym "Exploding Haggis".

Introduction

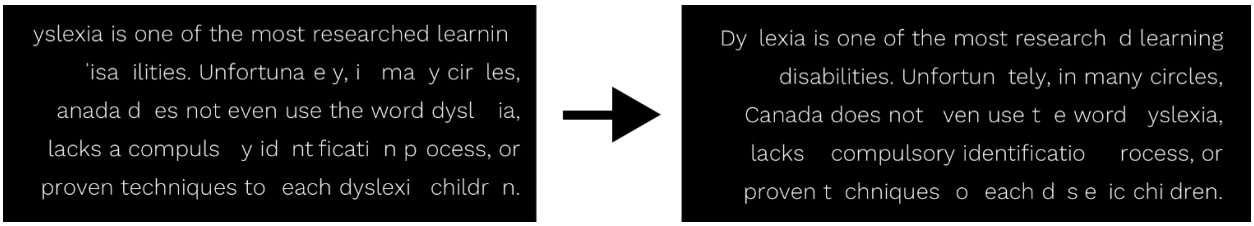
Why does understanding neurodiversity matter? The purpose of this piece spotlights my experience with dyslexia – the daily decoding of the world around me. My scholastic experience as a child was best characterized by evaluations stating I had "poor comprehension" or lacked verbal skills and understanding of social settings in the classroom. I was segregated from my classroom (at times left alone in a room for extensive periods) and ultimately made to feel isolated, dumb, ashamed, and unsafe. Dyslexia Canada notes how 40% of students with a learning disability also experience mental health issues. It is important to understand dyslexic or other neurodivergent students from an early age because we do not deserve to be dismissed as being slow or lazy learners. We see the world differently and that is ok.

A key first step to understanding is to **build empathy**. As a dyslexic person, I recommend starting with Dyslexia Canada's web experience It's Hard to Read Interactive Website.

Figure 2. Image from Dyslexia Canada – It's Hard to Read.

Note: It's Hard to Read. An interactive website to give non-dyslexic readers experience what it is like to read with dyslexia. In the image above, note how the smaller body copy appears scrambled or misspelled. This is what may appear for some dyslexics as letters may seem to jump around.

Figure 3. Optical Illusion that mimics dyslexia.



Note. This interactive website shows how letters may jump around. For example, the two images above show the same body copy where a dyslexic person may see nonexistent movement where the reader may see letters shift or jump from one image (left) to another (right) that may feel like an optical illusion to the reader. It is important to note that this is just one sensation, and that there is no single pattern that affects all dyslexic people. Reference URL: https://web.archive.org/web/20230306232954/https://itshardtoread.org/

The Dyslexia Canada website *expresses the dyslexic experience for non-dyslexic viewers*. This website employs similar visual elements and technique as my *Decoding* illustration but does so using motion which is a key part of the experience. For digital educational tools, it should be noted that the Accessibility for Ontario's with Disabilities Act (AODA) is the standard for accessible digital design across Canada with websites under scrutiny. As more technology enters the classroom, the standards outlined in the AODA on digital design and accessibility support should be questioned when developing design systems for the classroom.

Method

As a semi-autobiographical piece, the young boy in the image represents my experience with dyslexia. Letterforms are illustrated in a sloppy way which lose their form the farther they regress into the background. The way the letter forms scatter across the image represent how perception of letterforms may jump or scramble, which challenges the view to read slowly or work harder to understand what they are seeing. The intent behind this design decision was to challenge cognitive load in the viewer. In communication design the standard practice is to respect the finite information the audience can process, memorize and recall. By pushing cognitive load in the background of this image, I wanted to help the viewer empathize with the dyslexic experience.

The young boy pictured is alone and not in a classroom or social setting. This is a reference to my experience in the classroom which saw me placed alone in a separate classroom because I could not comprehend assignments or classroom settings. Research by Danika Overmars (2010) notes in The First Peoples Child and Family Review (Vol. 2, 2010), this is reflective of Western ways of knowing which "often exclude the spirit when attempting to understand people". This practice of compartmentalizing my inabilities had a detrimental impact on my confidence as a learner and on my sense of self.

Discussion

In the illustration, the boy is not looking back at the audience but rather staring off into space. This is indicative of people like me who may struggle with direct eye contact in social settings. But this is also indicative of how we process information. Dyslexics may tend to stare off into space or seem disengaged, when really, we are letting our minds ease into a neutral state which is how we begin to dissect a problem. This is something which compartmentalized me as a daydreamer or lacking comprehension in school, when in fact people like me are creative, good problem solvers, observant and highly empathetic.

With this experience in mind, I was fortunate to grow up on both Stó:lō and Sts'ailes land which presented an opportunity to learn with teachers who incorporated local Indigenous ways of knowing into their classrooms. This included spending time to "understand the spirit" of the learner. This practice helped me contrast my experience further towards understanding self-love/worth, thanks to being seen by certain teachers. This practice is referenced in The First Peoples Child & Family Review, which notes Indigenous perspectives on "valuing and honouring the spirit in the understanding of people." This statement stresses the "holistic worldview rather than the compartmentalization seen in Western ways of knowing." I found this fascinating as being seen is such a key part of the human experience, especially in the arts. In illustrating *Decoding,* I am asking the audience to see me, to see my kind, and hopefully come to feel some of what my experience is.

Though this art submission does not accept performance art, I would like to challenge the editorial team to explore the work of Marina Abramović's *The Artist Is Present* which explores human connection through *seeing* another human being. The performance engaged Abramović in a locked-eyed mutual gaze with gallery attendees, sitting in silence for a few short minutes. This work illustrated the importance of human connection which goes deeper than transaction-based or compartmentalized interaction.

Conclusion

In this piece, I am looking to evoke feelings of empathy. In communication design we often refer to this as design thinking which is the practice of developing empathy for the end user. I have outlined my scholastic experience from a neurodivergent perspective which could benefit from Indigenous ways of knowing, and with this in mind I want to end by inspiring ideas that may lead to collaborative paths forward for individuals in the arts and sciences.

1. **Exploring empathy through storytelling.**
   Prior to the interruption from colonial practices, Indigenous transfer of knowledge focused on storytelling and experiential learning which integrated with daily life and emphasised relationships. In my scholastic experience it was highly beneficial to learn from local artists and Knowledge Keepers in a full-body learning environment which was also relational with the arts playing a key role.
   To this end, I would like to encourage the editorial team to explore the childrens' book *Aaron Slater Illustrator*, by Andrea Beaty, and illustrated by David Roberts. Through art and storytelling, the book builds an empathetic and expressive picture of the dyslexic experience. The central character is based on artist Aaron Douglas, a dyslexic and key figure during the Harlem Renaissance.
2. **Addressing accessible design in education**
   Subtle yet significant design decisions in typography have a major impact on accessible design needs for learners. For example, sans serif fonts are typically easier to read for dyslexics. As we move further into more sustainable and digital design, consider working with designers who are familiar with the Association of Registered Graphic Designers (RGD) handbook on Accessible Design.
   The RGD highlights typefaces designed for dyslexics such as the *Sassoon* typeface for children, as well as *Sylexiad, Read Regular, Lexie Readbale, Dyslexie,* and *OpenDyslexic.* However, the RGD firmly states the inconclusive and mixed evidence regarding the efficacy of these typefaces. This is a key area of collaboration for education and design going forward.

Recommendations for Taking Action

1. The Basics of Dyslexia: https://dyslexiaida.org/dyslexia-basics/
   From the International Dyslexia Association, this source outlines mostly high-level references for understanding dyslexia.

2. Support for Dyslexia and ADHD: https://www.dyslexiavancouver.com/understanding-dyslexia-and-adhd, https://www.youtube.com/watch?v=ARNp9iZPFm4&t=808s&ab_channel=MargotYoung
   Dyslexia Vancouver has some great resources for supporting those with dyslexia and ADHD. There are common traits between the two such as difficulties with concentration, attention span, and time management. It is important to recognize that both experiences can lead to low self-esteem and mental health conditions noted in the Dyslexia Canada data.
3. Understanding the term *Neurodivergent*: https://my.clevelandclinic.org/health/symptoms/23154-neurodivergent
   This resource from the Cleveland Clinic touches on more high-level understanding of neurodiversity as whole, what are other conditions in addition to Dyslexia or ADHD, how to support children who may be neurodivergent, and the importance of highlighting our strengths.
4. The Strengths of Dyslexia: https://www.dyslexiasupportsouth.org.nz/parent-toolkit/emotional-impact/strengths-of-dyslexia/
   It is important to emphasize that we are different and not deficient.
5. Supporting Neurodiversity in the Classroom: https://www.mheducation.ca/blog/neurodiversity-in-the-classroom
   This resource from McGraw Hill highlights the need for creating a safe space which is free of judgement and leverages active listening. In my personal experience, the latter benefited me as I felt seen or understood by a teacher. This was a less transactional learning experience. People like me want to be seen, heard, and free to speak our truth.
6. We Want to Be Understood: https://www.understood.org/
   Understood.org has resources which can be tailored based on experience. Their web experience is a nice example of recognizing some accessibility design standards for digital design. This is key when understanding sensory triggers in neurodivergent people.

References

Aaron Douglas bio, National Gallery of Art, https://www.nga.gov/collection/artist-info.38654.html

Aaron Slater Illustrator, Andrea Beaty, (2021). Visual storytelling for children who may struggle with comprehending letterforms: https://www.richlandlibrary.com/blog/2021-11-02/newest-questioner-aaron-slater#:~:text=The%20character%20Aaron%20Douglas%20Slater,the%20National%20Gallery%20of%20Art.

Dyslexia Canada, It's Hard to Read, (2021). An immersive digital experience that gives you an insight into what it's like to live with dyslexia. Dyslexia Canada advocates for fair and equitable education for all Canadian children with dyslexia: https://itshardtoread.org

MoMA Learning, The Artist is Present by Marina Abramović, (2010). Art installation with the intent to illustrate the concept of forming human relationships by understanding another person's Present emotions. https://www.moma.org/learn/moma_learning/marina-abramovic-marina-abramovic-the-artist-is-present-2010/

Overmars, D. (1). "Diagnosis as a Naming Ceremony: Caution Warranted in Use of the DSM-IV with Canadian Aboriginal Peoples". *First Peoples Child & Family Review*, *5*(1), 78-85. Retrieved from https://fpcfr.com/index.php/FPCFR/article/view/176.

The RGD AccessAbility 2: A Practical Handbook on Accessible Graphic Design, (2021). The Association of Registered Graphic Designers (RGD) in partnership with the Government of Ontario and The Accessibility for Ontarians with Disabilities Act (AODA) which seeks to provide accessible standards for all through both legal compliance and improving quality of life. https://www.rgd.ca/resources/accessibility/access?gclid=EAIaIQobChMIjv-Xst7agAMV0gytBh208gVFEAAYASAAEgLdQ_D_BwE.

PROPOSING HOW ART COULD BE USED TO EDUCATE SCIENCE

HOANG LE DO
Emily Carr University of Arts and Design

Abstract

The paper examines theories and examples between art and science, showing where they are similar, and how art and design can be used to educate and inform scientific data. Due to how vast both fields are in terms of specializations, theories, and practices, I aim to do so by focusing on and comparing theories of physics, mainly those related to Isaac Newton, and art and design's color theories, showing how they are similar, and then proposing how art could be a bridge between science and the learner, how knowledge could be delivered as an experience.

Keywords: Art, Design, Science, Color, Physics, Theories, Knowledge, Experience

Proposing How Art Could Be Used to Educate Science

While I'm a design student with a year left for his bachelors, I have been studying and practicing art and design for more than a decade. I am interested in topics of science but sometimes am not capable of comprehending certain subjects, which is why I have been looking for ways where my practices can help make science more digestible for the general public.

Although science and art have numerous specializations and theories, this paper will only examine laws of physics, mostly related to Isaac Newton, and theories of color, one of the many bridges between art and science, and where art and science could meet.

Sir Isaac Newton (25/12/1642 - 20/3/1726-27) was an important physicist, whose many discoveries included the enigmatic force, gravity. Gravity soon became the foundation for physicists that succeeded him, one of them was Albert Einstein, the proponent of the theory of General Relativity. General Relativity is a theory that examined how gravity affected space-time and refined the concept of gravity into how it is commonly understood today (Tillman et al., 2022). Many studies of physics continue to rely on Newton's foundations (Maranzani, 2020).

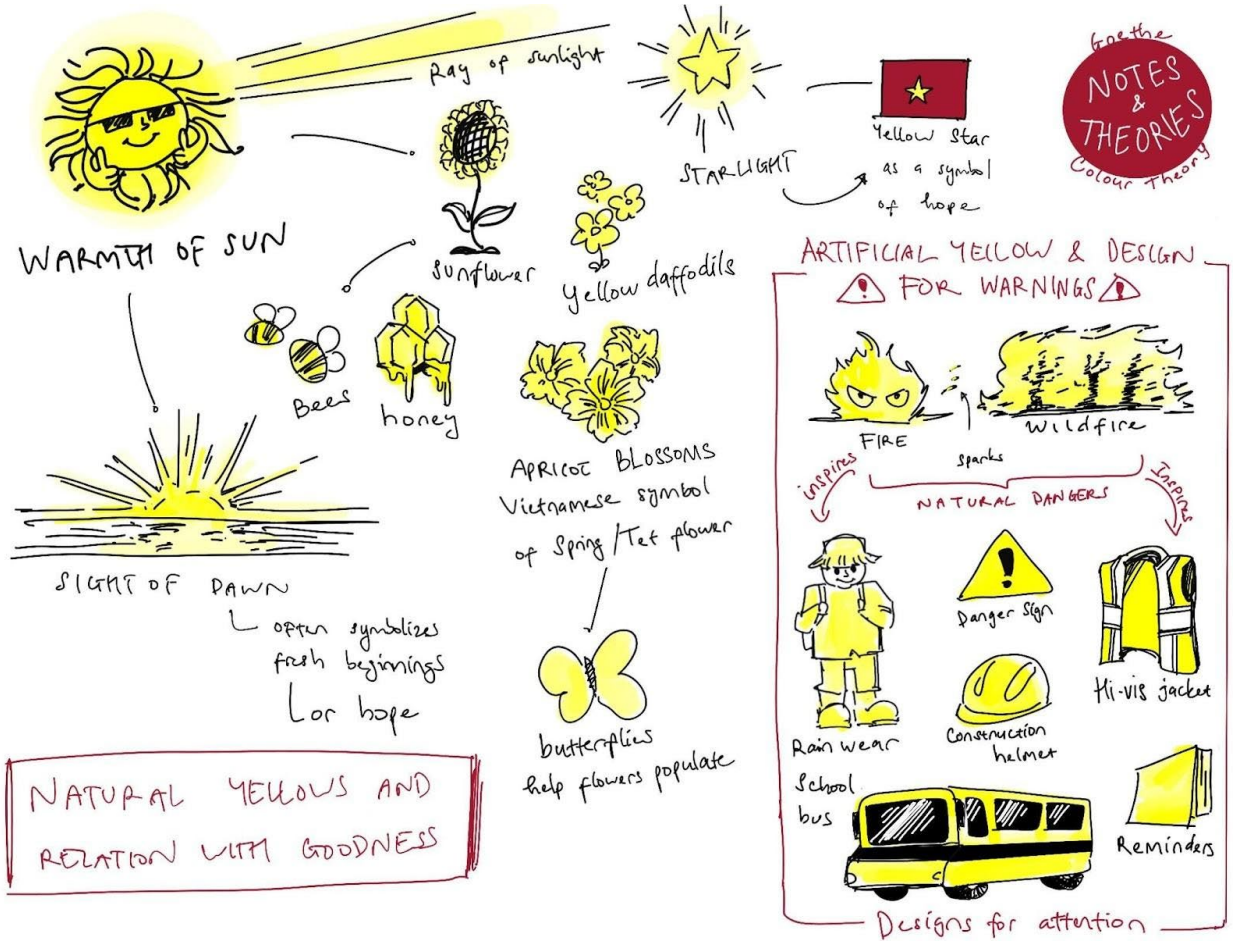
Figure 1: *The story of Newton and the Apple.*

Note. Comic about the story of an apple falling on Newton's head. Created by Hoang Do. Used with permission.

Newton also studied light, devised a Theory of Colors, and deduced that white sunlight was composed of different colors (Gencer, 2020). However, artists and designers have studied the mechanics of colors from another figure, Wolfgang von Goethe.

German artist Wolfgang von Goethe (28/8/1749 - 22/3/1832) once said "Colors are light's suffering and joy", and published a treatise called *Theory of Colors* (1810), wherein colors were proposed to be perceived more subjectively based on the relationship between colors, and the psychological and emotional states of the beholder. For instance, Goethe proposed that yellow was associated with good, serenity, and brightness, and blue with shadows, coldness, calm, and stillness (Popova, 2021).

Figure 3: *My digitized observations and theories whilst studying Goethe's theory.*



Note. In case the figure is in black and white, the objects observed are yellow, and thus appear light gray. Created by Hoang Do. Used with permission.

Figure 4: *Flowers in vase (left) and Van Gogh in field (right). Oil on canvas.*

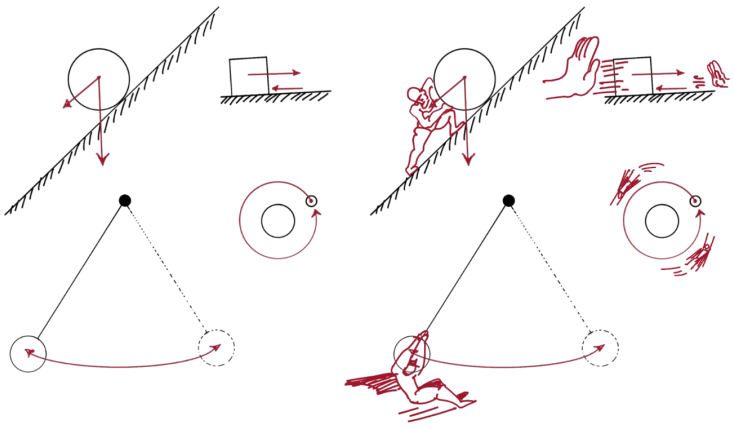
Note. I applied Goethe's color theory while painting these, where I used yellow and blue to convey light and darkness, as well as emotional states, not to capture reality, but to convey experience. In case the figure is in black and white, the lighter areas of the paintings were colors mixed with yellow, and darker areas were colors mixed with blue. Created by Hoang Do. Used with permission.

While different practices and mediums have relied on different theoretical foundations and artistic movements, Goethe's Color Theory has helped artists and designers decide what color to choose to turn an objective landscape to a subjective emotionally charged painting (Figure 4), or what color a furniture or item of fashion should have, or what color a fictional character should wear. Goethe's theory mainly taught artists and designers to convey meaning with colors.

As shown, art has theoretical foundations similar to science that are applied in practice and live in methodology. From my experiences and practices, I have speculated about how practices of art and design could educate science.

I chose these topics to talk about because physics was my worst enemy in high-school, and I only managed to pass by doodling relentlessly on textbooks. Not only were the books filled with difficult concepts, but boring illustrations as well. However, seeing those graphs in my own ways made it easier, because I was relating challenging ideas with experiences and topics that I was excited for (Figure 5).

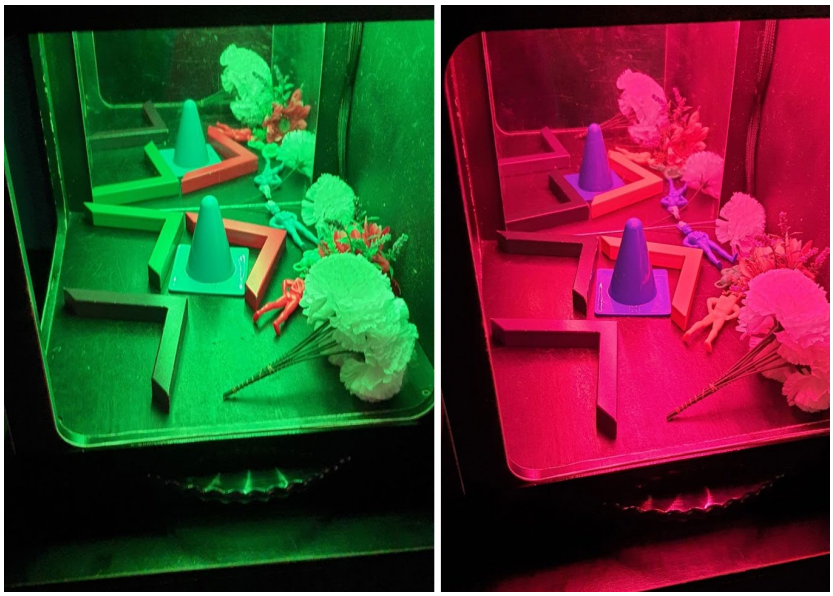
Figure 5: *Representation of my highschool physics textbook.*



Note. Textbook illustrations turned into comics. Created by Hoang Do. Used with permission.

Based on these personal experiences, I have concluded that art should be used to make scientific data more appealing and comprehensible. Newton's or Einstein's complicated theories could be made comprehensible even for children if it was portrayed in a gallery or exhibit, science fairs and science museums, such as those in Vancouver's Science World (Figure 6).

Figure 6: *Science World's interactive attraction that shows how color is reflected off of objects.*



Note. In case the figure is in black and white: The box is green, but certain objects appear red (left), and while the box is red, certain objects appear blue (right).

While Newton analyzed how colors work objectively, Goethe's research proposed how they could be interpreted subjectively based on personal experiences. From this, I propose that ordinary people can engage with intellectually challenging knowledge of science through a methodically designed artistic experience acting as the bridge in between, for instance, science attractions such as figure 6 deliver science to the people using experiences and interactivity. Even children could enjoy these complicated theories through these experiences, from cartoons, movies, or toys to attractions, etc. Understanding the light spectrum could be made easier if one could play with a prism and see how light splits into different colors, and passing high school physics might be easier with colorful comical graphs.

In closing, art is a methodical and thoughtful practice, and could also be used as a bridge between levels of intelligence. Art and design could simultaneously use theoretical foundations and practical applications to give the public comprehensive access to advancements and knowledge of science, where instead of simply to inform, knowledge is experienced in artistic and creative ways.

References

Tillman, N. T., Bartels, M., & Dutfield, S. (2022, January 5). *What is the theory of general relativity?*. Space.com. https://www.space.com/17661-theory-general-relativity.html

Maranzani, B. (2020, June 2). *How Isaac Newton Changed Our World*. Biography.com. https://www.biography.com/scientists/how-isaac-newton-changed-our-world

Gencer, E. (2020, June 16). *Newton and the science of color.* Columbia Science Review. https://www.thecolumbiasciencereview.com/blog/newton-and-the-science-of-color

Popova, M. (2021, June 2). *Goethe on the psychology of color and emotion*. The Marginalian. https://www.themarginalian.org/2012/08/17/goethe-theory-of-colours/

CRITICAL PEDAGOGY: A CREATIVE ARTISTIC REPRESENTATION ABOUT PAULO FREIRE'S WORK

DJEISON HOERLLE
Unisinos University
EDUARDO RIBAS
Santa Cecilia University

Abstract

This paper, entitled "Critical Pedagogy: A Creative Artistic Representation of Paulo Freire's Work", aims to discuss Freire's work in a disrupting way. To do so, from a theoretical point of view, it drew on Giroux (1989), with the regard on critical pedagogy, based on Freire's work. Finally, it is believed that this creative artistic representation shows the importance on Freire's way of teaching and, after all, his contributions to a non-traditional teaching.

Keywords: Critical Pedagogy, Freire's work, Comics.


AS YOU KNOW, MR. PAULO, IT WASN`T THE FIRST TIME THAT WE RECEIVED SOME COMPLAINS ABOUT YOUR "METHODS".
TEACHER IRENE TOLD US THAT THE NOISE COMING FROM YOUR ROOM WAS DISTURBING HER CLASS.
IT WAS SO LOUD THAT HER KNOCKS WERE NOT EVEN HEARD.
SHE WAS PERPLEXED BY WHAT SHE SAW.
THIS IS A TRADITIONAL SCHOOL. I'M SURE PARENTS WOULD HATE TO KNOW THAT THEIR KIDS ARE GOING TO SCHOOL JUST TO PLAY.
NONSENSE, THEY WERE LEARNING.


LEARNING? BUT YOU DIDN'T EVEN BOTHER TO WRITE SOMETHING ON THE BOARD FOR THEM TO COPY, MR. PAULO!
IT'S BECAUSE I WAS BUSY.
BUSY? PLAYING?
NO...
I WAS LEARNING, TOO.

Critical Pedagogy: A Creative Artistic Representation of Paulo Freire's Work

Paulo Reglus Neves Freire was one of the most notable names in the world of pedagogy and one of the main influencers of the movement called critical pedagogy (Giroux, 1989). Critical pedagogy proposes the role of the teacher not only as a mere transmitter of knowledge, but mainly, as an awareness-raising agent, helping the student in understanding the social context in which he is inserted, and how such context influences freedom for an individual - or in the absence of it.

Despite his notorious theoretical relevance, as it was a line of thought strongly influenced by Marxist theory, Freire had a tiny space for the application of his theories. In 1964, less than a year after the experiment - also widely referred to as a revolution - of Angicos, in which the educator and his team taught more than 300 adults to read and write in 40 hours, the military dictatorship was established in Brazil, and Freire was one of the first prisoners and exiles in the regime. The conception of the Angicos experiment as a revolution was due to the fact that, in the context of its execution, voting was a right of only the literate - a fact that would only be changed at the end of the dictatorship in 1985, revealing the paradoxical captivity of the prevailing inequality at the time, because by denying the right to education, the voices that most needed to be heard were silenced.

Despite having well-achieved ideals, critical education does not have a set of defined methodologies, since one of its precepts is precisely the understanding - and consequently, the adaptation - to the context in which it is applied. In the comic presented here, we seek to disentangle Freire's ideas from the classical representations linked to the bucolic environment, choosing to imagine a a group of children between 8 and 10 years of age in a traditional school. Freire, as a theoretician, made a point of constantly pointing out the need to combat the oppressor; however, without ever assuming his role - it is fair that we as artists use our class as justification to represent a much more utopian representation of its application, to educate today's children without ever depriving them of their own childhood. This is the way in which we hope not only to avoid the formation of new oppressed people, but above all, of new oppressors in the coming day.

References

Giroux, H. (1989). Critical Pedagogy: The State, and Cultural Struggle. New York: State University of New York Press.

Biographies

Djeison Hoerlle is a Brazilian writer, director, and designer. Since he was 12 years old, he has been telling everyone that he will become a great writer. On the other hand, he only started to tell his own stories during the pandemic, as a way of dealing with his fears and insecurities by means of the webcomic "Perda." Since then, he has written the comics "Jardim das Ideias", "Palhas e Penas – As Crônicas de Tomás e Fel" and "O Colecionador", in addition to several poems and short stories. Moreover, he acts as a film, literature, and comic critic on his Medium page.

Eduardo Ribas started drawing comics in 2017 by publishing "O Jogo mais Difícil do Mundo." Always working independently, he made an average of two comics per year, such as the sword and magic trilogy "Três Reis", the comic book "Desconexo" that simulates a bank robbery with hints of surrealism and the daily life comic "Até depois, amor." In 2020, the comic book "D.I.V.A.S Brasileiras", awarded with the public notice Funarte Descentrarte and written by Guilherme Smee, was a finalist in the main Brazilian comics awards. Similarly, the comic book "Uma Nuvem no Seu Oliveira", written by Phellip Willian, was successfully financed by Catarse and HQMix finalist of the following year.

INTEGRATING ART INTO STEM: AN INTERSUBJECTIVE AND PARTICIPATORY EXPERIENCE WITH FELLOW SUBJECTS

TANYA J. BEHRISCH
Simon Fraser University

Abstract

Integrating artistic practice into STEM to create STEAM offers learners intersubjective experience with subjects they study. This contrasts with traditional STEM education which upholds an ontological belief in human separation from the world they observe. This ontological separation justifies the absence of ethical considerations towards those subjects we study. In the context of our environmental crisis, this is problematic because humans are neither separate nor free from ethical ties to those we study. Rather, we are dependent on those who spark our curiosity and sustain our lives. Integrating artistic practices such as oil painting into STEM education brings intersubjectivity into scientific learning. Creating art depends on treating our affective and embodied responses to subjects as valid data and sources of knowledge. This brings learners into dialogue with fellow subjects and shifts from a traditionally objectifying stance towards one of kinship. The author demonstrates her embodied dialogue with a wild doe through various stages of painting an image of the doe onto plywood. Her creative process shows a participatory relationship arising between herself as researcher and the doe, her fellow subject. Throughout the painting's development, diverse subjectivities emerge, including the doe, the plywood and the author, creating a participatory collaboration and an intersubjective experience. This article draws on David Abram's and Goethe's theories of participatory observation and embodied knowledge of 18th-century artisans.

keywords: Artistic practice, Oil painting, STEM, Intersubjectivity, Animal, Plywood, David Abram, Goethe.

Introduction

Traditional STEM education teaches that humans are separate and unrestricted by ethical considerations towards the world they study. In the context of our environmental crisis, this is a problem. Humans are neither separate nor free from ethical ties towards those we study. Instead, we are dependent upon and beholden to the world that sustains us. Notions of scientific objectivity and detachment are false conceits that need rethinking. Integrating relational, subjective and ethical considerations into STEM education offers learners intersubjective experiences and empathy towards their subjects.

Artistic practices such as writing and oil painting are subjective, intersubjective and affective experiences. These experiences forge relational connections with others, including those we study. The artist taps into feelings arising during the creative process. Attuning to my affective response while making art creates space to be in dialogue with my fellow subject. Through dialogue, I shift from objectifying those who interest me as passive objects towards being in community with them as fellow subjects. This shift offers potential for kinship with other subjects. Kinship implies *we* instead of *me as objective scientist* observing a passive object. A kinship ontology implies I have obligations towards my kin, my fellow subjects, including those I seek to understand through science. While traditional STEM education separates learners from the world we study, art involves us personally and affectively, offering us intersubjective experiences with our fellow beings. Thus, given our current ecological crisis, integrating artistic practice into STEM to create STEAM makes good pedagogical sense.

As artist-author of this paper, I demonstrate my dialogic embodied conversation with a wild doe I encountered in June 2022. This process is illustrated through various stages of a painting in progress (see Figures 1-5).

Figure 1. *A Wild Doe Emerges as A Fellow Subject Through the Artistic Practice of Oil Painting. Oil On Plywood, 24 X 20 Inches, 2023. Painting By Author.*

My creative process shows a participatory relationship arising between myself, as I seek to understand my fellow subject, the wild doe. Throughout the painting's development, diverse subjectivities emerge, including the doe, the plywood and myself, giving rise to an intersubjective experience for myself and possibly others with whom I'm in dialogue. While participation, intersubjectivity and embodied knowing are integral to artistic creation, these qualities are not recognized in traditional STEM education. However, examples of these qualities exist in particular pockets of Western epistemology. Three examples are discussed below.

Participatory Observation, Intersubjectivity and Embodied Knowing: Goethe's Delicate Empiricism, Abram's Phenomenology and Artisanal Embodied Epistemology

Goethe's 18th-century epistemology recognized the reciprocal relationship between Goethe the scientist and the world he studied. Goethe coupled direct embodied experience in nature with careful observation. This coupling gave rise to a dynamic dialogic relationship between Goethe the scientist and the natural world he studied. When observing beings in nature such as animals and plants, Goethe perceived them as active participants in his experience of observation. For Goethe, this fostered empathy for those organisms, formed the basis for his participatory scientific method (Wahl, 2005, pp. 58–61).

While traditional STEM education relies on isolating phenomena, Goethe's method was to leave beings integrated and intact within their familiar context. This method was called "delicate empiricism." It enabled him to observe organisms functioning within whole ecological systems in which he saw himself as an active participant. Goethe often incorporated artistic practices such as drawing and poetry into his observations of nature. Goethe's epistemology, which included participatory observation, delicate empiricism and art, is an example of intersubjectivity in Western science. His use of intuition in his scientific method shares an element of intersubjectivity with artistic creation (Wahl, 2005, p. 58).

Similarly, phenomenologist David Abram emphasizes the embedded participatory role of observer within the world. He describes the "active interplay" between observer and fellow subjects (1997, p. 57). Abram's epistemology builds on phenomenological theories of earlier thinkers such as Husserl, Merleau-Ponty and Levy-Bruhl. He argues that Cartesian science, upon which traditional STEM education relies, falsely dualizes and separates scientist from her inner and outer worlds.

Cartesian dualism isolates the scientist's intellect from her body and from the world she studies. For Abram, these separations are mistaken. They deny integration of the human mind within the body, as well denying human dependence on our surrounding ecology. Like Goethe's participatory observation, Abram proposes that humans, including scientists, collaborate with fellow subjects in a subjective sentient world. He perceives reciprocal participation between the observer and the observed. This relational dialogue is an ongoing process that never stops. "Neither the perceiver nor the perceived, then, is wholly passive in the event of perception… since the act of perception is always open-ended and unfinished, we are never wholly locked into any particular instance of participation" (Abram, 1997, p. 53, 59). For Abram, making art is a way to forge reciprocal and collaborative relationships with our fellow subjects.

> Genuine artistry… does not impose a wholly external form upon some ostensibly 'inert' matter, but rather allows the form to emerge from the participation and reciprocity between the artist and his materials, whether these materials be stones, or pigments, or spoken words (Abram, 1997, p. 288).

Themes of active participation and reciprocity that emerge in Geothe's and Abram's epistemologies resonate with the embodied knowledge of 18th-century artisans described by Smith (2004). Artisans work with their whole bodies, including their hands *and* minds which are located in the body, to create artifacts such as decorative art and tools. Smith argues that 18th-century artisanal knowledge represented an embodied epistemology of nature, a way of understanding the world through physical contact with the world.

> For artisans, experience and the production of things were bound up with their own bodies… they articulated in their writings and in their works of art a view that certainty is located in matter and nature and that knowledge can be gained by observing and experiencing—often by bodily struggle—the particularity of nature (Smith, 2004, p. 6).

Dominant 18th-century European ontology dualized mind over matter. Mental cognition was held in higher esteem than embodied knowledge. Because artisans worked with their hands and bodies, their work was regarded as lower status than abstract cognitive work (Smith, 2004). However, as 18th-centure artisans took on increasing commissions from wealthy patrons, their embodied knowledge and skills gained increasing respect (Smith, 2004, p. 8).

The embodied nature of 18th-century artisanal epistemology resonates with Goethe's participatory observation and Abram's phenomenology. Artisanal knowledge was developed *only* through direct embodied experience. "We can find in their works both epistemological claims—what I call the "artisanal epistemology"'—as well as a vernacular "science" of matter" (Smith, 2004, p. 8). Integrating embodied, artisanal and artistic practice into STEM brings embodied epistemology into dialogue with traditional scientific epistemology. This confluence taps into what Smith calls artisanal "non-verbal literacy" and "material language" offered by embodied artistic practices (Smith, p. 8, 2004).

Integrating Art into STEM To Make STEAM

Educators recognize that artistic practice enhances creativity and problem solving and builds cognitive and social skills. Integrating art into STEM improves student engagement, innovation and collaboration (Perignat & Katz-Buonincontro, 2019, pp. 31–32). The reasons behind art's benefits to cognitive processes and skills are unclear since artists' methods are not easily measured, observed or quantifiable. Artistic knowledge arrives through intuition and embodied processes while making art; not looking at art or thinking about art, but *doing* it with our hands, bodies and inner emotions. These qualities involve us in a reflexive dialogue with our fellow subjects we seek to understand.

Writing scholar Elizabeth Adams St. Pierre writes about how "fugitive, fleeting" knowledge arrives *only through* the embodied and affective experiences of writing.

> These data were neither in my interview transcripts nor in my field notes where data are supposed to be, for how can one textualize everything one thinks and senses in the course of a study? But they were always already in my mind and body, and they cropped up unexpectedly and fittingly in my writing—fugitive, fleeting data that were excessive and out-of-category. My point here is that these data might have escaped entirely if I had not *written*; they were collected *only in the writing* (Richardson & St. Pierre, 2011, p. 829, emphasis in original).

St. Pierre's claim about writing as an embodied portal to knowledge can be transposed to other artistic practices such as oil painting. In exploring the intersection between art and traditional STEM education, I engage with a wild doe through my creative practice of oil painting and through consulting scientific texts about the doe's physiology and adaptation to her native environment. I painted on scrap plywood found on the Francis Peninsula, B.C., close to my encounter with the doe (Figure 1).

Plywood: Dialogue with Ancient STEM Technology

Plywood is an ancient technology developed by ancient Egyptians and Greeks. They found that by placing thin layers of wood together at 90-degree angles and adhering them together, a building material stronger than solid wood was created for building and decoration. This was particularly useful in areas where wood was scarce ("Plywood," 2023). Still used today, this ancient STEM technology beautifully exemplifies the intersection of science, technology, and the natural more-than-human world. Plywood's material is earthen. Each layer, or ply, demonstrates organic processes that supported trees' absorption of water, nutrients and light, including seasonal cycles and rainfall. The technology is human and embodied; made of thin layers of wood, the whorls on plywood's surface are trees' seasonal three-dimensional growth rings flattened into two dimensions (Figure 2). By painting on this technical organic material, I integrate ancient STEM with art and more-than-human processes such seasonal change.

Figure 2. *Whorls And Knots Indicate Seasonal Growth Rings On Plywood*

Scientific Data Objectifies the World

Before beginning my painting, I consult scientific texts to learn about the doe's physiology, behavior and adaptation to her environment. White patches on her belly, neck and legs distinguish her as a Coast Deer, also known as a Columbian Blacktail. She's subspecies of the Blacktail Deer (Grzimek, 1973, McTaggart Cowan & Guiguet, 1978, p. 366). She eats succulents and swims between islands off the B.C. coast. Further scientific facts:

> Weights of adult males *including viscera* may vary from 110 to 250 pounds; females 70 to 140 pounds, fawns at birth 3 to 6 pounds; *deduct one-fifth for dressed weight* (McTaggart Cowan & Guiguet, 1978, p. 367, emphases added to original).
>
> Bucks castrated after the eighth month develop permanent misshapen antlers that do not lose the velvet (McTaggart Cowan & Guiguet, 1978, p. 368).

These scientific metrics objectify the deer. They deny an ethical obligation to respect her innate right to exist outside of scientific fact finding. Do we really need to know what happens to a buck's antlers after he is mutilated through castration? This false assumption of scientific detachment contributes to our ontological crisis of separation from Earth's creatures, our fellow subjects. Introducing artistic practice into scientific research allows us to relate to those we study. It invites us to recognize fellow subjects as agentic, sentient and worthy of ethical consideration.

Entering Into Conversation with A Fellow Subject

Instead of objectifying those we study, queer theorist Halberstam invites us to become involved in conversation with them. "Conversation rather than mastery … seems to offer one very concrete way of being in relation to another form of being and knowing without seeking to measure that life modality by the standards that are external to it" (2011, p. 12). Oil painting is akin to having a conversation with a fellow subject. Iterative, the artist responds to her subject taking shape over time. The doe prompts me to look at her gently, to not force her form into being. Her graceful form in the photograph asks me to keep my early sketching fluid and light-handed. The weathered plywood too implores me to paint lightly so that its hairline cracks, whorls and knots remain visible through the oil pigment (Figures 1-5).

Feelings arise within me as I observe the doe's graceful relaxed form. Her resilience and dignity as a fellow being affect me. I feel myself moving towards her as she emerges. I want to honor her as a fellow being. She manages to survive and procreate in this coastal environment that's increasingly encroached upon by suburban development (Figures 3, 4 and 5). Sketching the doe's contours (Figures 3 and 4), I feel nervous I'll fail to depict her grace and form. This feels dishonorable to this beautiful fellow being. I undergo an onto-epistemological shift through the painting process, which I detail below.

Artistic Practice Involves Surrendering What's Known

I need to surrender what I *think* a doe looks like and refer back to the photograph I took in June 2022 during her tacit permission to be near her. Sketching multiple contours of her form, I struggle to get her posture right (Figure 3). I take a break from painting to pour myself a glass of water. As I re-approach the painting, I tell myself,

"you're safe from perfection here; no one's expecting anything from you. Relax. This isn't serious. This is you, the doe and plywood. Take your time. *Slow down.* It's going to be okay. There's no right or wrong here."

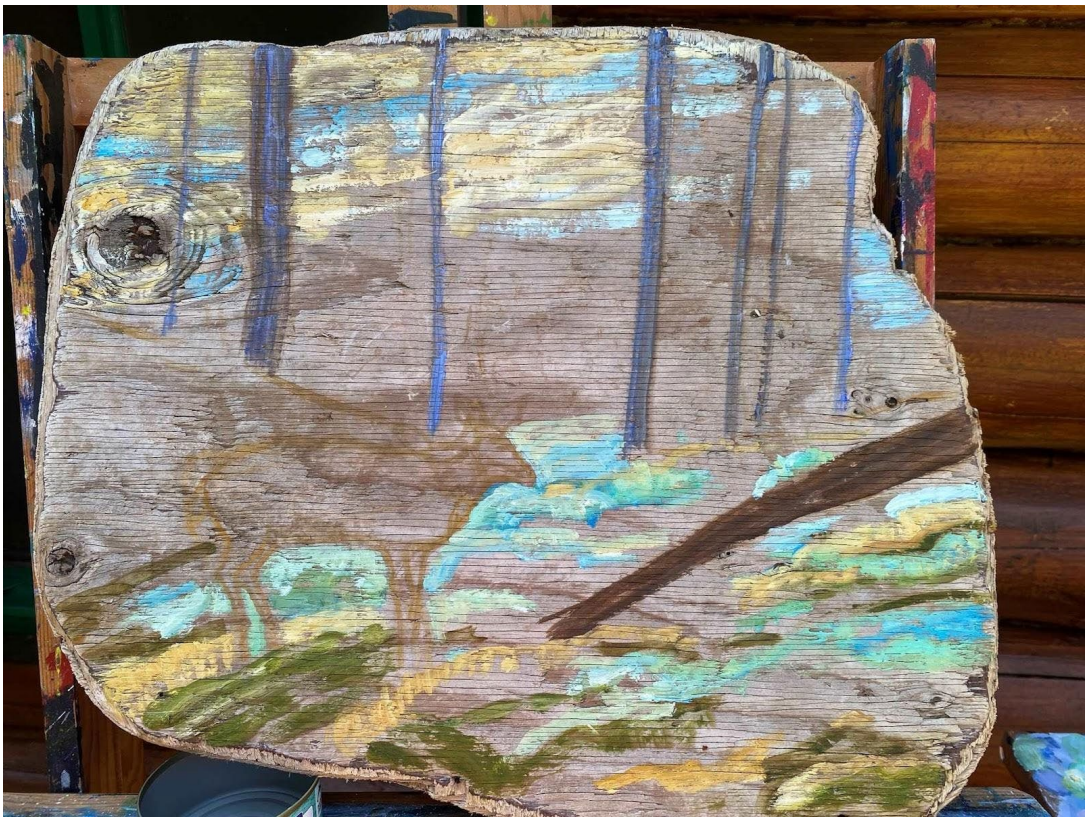
My self-soothing helps quell the encroaching feeling of inadequacy that's creeping in while painting. This embodied sense of inadequacy is a common feature in my artistic process. I learn how to handle fear of failure through *doing* art. Not by looking at art or thinking about art, but by doing it, with my mind, body and feelings. Somehow, I come to understand more about the doe through my fear of failure coupled with my action of self-soothing. My contact with her emerging form pacifies these swirling insecurities. She speaks to me as she comes into being we're in dialogue. She assures me I'm okay as a fellow being. She tells me I'm allowed to paint her because I respect her. This an intersubjective exchange between the doe and me.

Artistic Knowledge Arrives Through *Doing* Art

The drive towards precision and faithful rendering is a self-inflicted burden. I shake these unrealistic standards off like parasitic insects sucking my blood. This shrugging free comes only through the process of creating the painting of the doe. "There is so much more than the artist and the experience. There is the representation of that experience (and the materiality of that representation), as well as the *process of creation*" (Cutcher, 2007, p. 79, emphasis added to original). It's in this process of creation that I perceive the doe as an active agent.

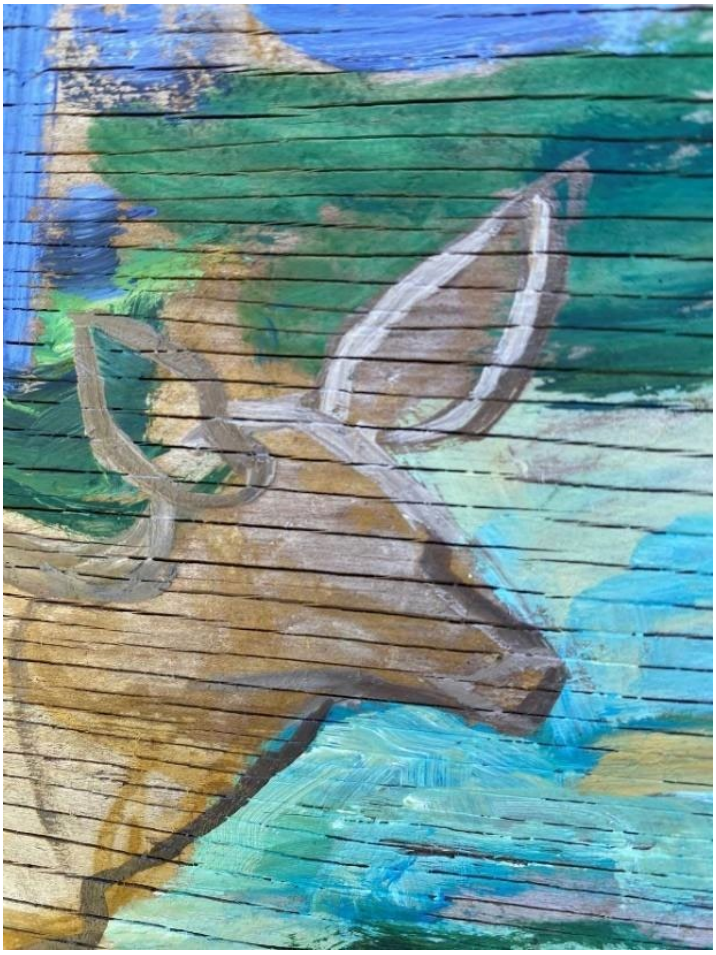
She is not a passive object provided by nature to me for detached scientific observation. No. I feel empathy for her as a fellow animal, a wild female creature who let me be near her despite having good reasons to mistrust me as a human. Exchanging the word 'painting' for 'writing' in St. Pierre's earlier quote, "these data might have escaped [me] entirely if I had not *painted*; they were collected only in the *painting*" (adaptation of quote in Richardson & St. Pierre, 2011, p. 829, emphasis in original). Empathy is absent from traditional STEM education. How can we feel empathy for insentient objects from which we are separate and autonomous?

Figure 3. *While Sketching, I Feel Nervous About Failing To Depict The Wild Doe Respectfully*



The dry plywood pulls pigment thirstily from my brushes. The doe, the trees and ancient STEM look back at me as speaking subjects, reminding me I'm not the sole knowing subject in this process. My relationship with these subjects grows as our entangled collaborative project takes shape. I peer at the doe's seemingly unconcerned expression. She reposed with me for 10 minutes, affirming I was no threat to her. I feel kinship with her as she emerges in Figures 3-5.

Figure 4. *Sketching The Doe's Head and Ears*



Note. Her large hears tell me she is prey to others and needs good hearing to survive.

The Experience of Intersubjectivity

The wood says, "My worldly travels are part of this painting. I want them to show up within the work." I surrender to the more-than-human voice of the plywood and paint with soft brush strokes and minimal pigment. I don't have to get this 'right.' What I need to do is show up, listen to the doe and the wood and follow what they're asking me to do. We are collaborators co-creating this painting together.

Creating art relies on my embodied feelings as a valid source of knowledge. I come to know the doe as a subject rather than as an object observed from a distance. My transcendent feeling of kinship during my encounter with the doe echoes in my experience of painting her. I want to know her and be known by her as a fellow being.

Figure 5. *As the Doe Emerges, I Experience Intersubjectivity with Her As A Fellow Subject*

"We ache to meet the limit of the human world, and to look past it" (Giggs, 2021 as cited in Klinkenborg, 2021, p. 4). My artistic knowledge arrives independently of rational logic upon which traditional scientific inquiry depends. "Art-based methods [make] use of a larger spectrum of creative intelligence and communications, generate important information that often feels more accurate, original, and intelligent than more conventional descriptions" (McNiff, 2012, p. 30). I experience intersubjectivity between myself, the doe, and the wood. I have not created this painting (Figure 1) alone but with collaborators participating in the painting's becoming.

Conclusion

Art validates embodied affective responses as reliable knowledge sources. It offers language where we often lack words to describe or quantify what we are sensing. Doing art extends our vocabulary, spoken and unspoken, relating to those whom we seek to understand. Art invites fellowship with subjects we study, potentially shifting our stance from separation to kinship with the world. This ontological shift draws on Goethe's and Abram's epistemologies of participatory observation where we ourselves are observed while observing others.

When doing art, we may gently retire Cartesian dualisms. Instead of gazing objectively at mute objects with which we have no relationship, we discover we are connected to these fellow subjects in myriad ways that move us affectively. Through the practice of oil painting, I experience my affective embodied involvement with multiple subjectivities such as the doe and the plywood. Integrating art into STEM invites humans, including scientists, to co-arise with our fellow subjects.

Gathering knowledge is not neutral but laden with relational and ethical implications towards those we seek to understand through scientific inquiry. Through oil painting, I undergo an intersubjective experience with the doe. Intersubjectivity is akin to Halberstam's conversation with fellow subjects rather than scientific mastery over mute objects. Our embodied affective responses to fellow subjects are critical to understanding our reliance and relationships with multiple subjectivities. Art reconnects us to ourselves, our bodies, feelings and fellow subjects. In the context of species extinction and the climate crisis, integrating art into STEM education is critical to raising ecological understanding, empathy and kinship among educators and learners.

References

Abram, D. (1997). *The spell of the sensuous: Perception and language in a more-than-human world*. Vintage Books.

Cutcher, A. (2007). Boundary hunters: Art for the sake of research. In J. G. Knowles, T. C. Luciani, A. L. Cole, & L. Neilsen (Eds.), *The art of visual inquiry* (Vol. 3, pp. 75–86). Backalong Books.

Grzimek, B. (1973). *Grzimek's animal life encyclopedia mammals 4.* Van Nostrand Reinhold Company.

Halberstam, J. (2011). *The queer art of failure*. Duke University Press.

Klinkenborg, V. (2021, August 19). Requiem for a heavyweight. *The New York Review of Books*. https://www.nybooks.com/articles/2021/08/19/whales-requiem-for-heavyweight/

McNiff, S. (2012). Art-based research. In *Handbook of the arts in qualitative research: perspectives, methodologies, examples, and issues* (pp. 29–41). SAGE Publications, Inc.

McTaggart Cowan, I., & Guiguet, C. (1978). *The mammals of British Columbia*. Province of British Columbia, Ministry of the Provincial Secretary and Travel Industry.

Perignat, E., & Katz-Buonincontro, J. (2019). STEAM in practice and research: An integrative literature review. *Thinking Skills and Creativity*, *31*, 31–43. https://doi.org/10.1016/j.tsc.2018.10.002

Plywood. (2023). In *Wikipedia*. https://en.wikipedia.org/w/index.php?title=Plywood&oldid=1159535754

Richardson, L., & St. Pierre, E. A. (2018). Writing: A method of inquiry. In N. K. Denzin & Y. S. Lincoln (Eds.), *The SAGE handbook of qualitative research* (5th edition, pp. 818–835). SAGE Publications.

Smith, P. H. (2004). *The body of the artisan: Art and experience in the scientific revolution*. The University of Chicago Press. http://hdl.handle.net/2027/heb06680.0001.001

Wahl, D. C. (2005). "Zarte Empirie": Goethean science as a way of knowing. *Janus Head*, *8*(1), 58–76.

SFU Educational Review Journal
Faculty of Education
Simon Fraser University
8888 University Drive
Burnaby, BC Canada
V5A 1S6

sfuedr@sfu.ca
sfuedreview.org