Ecology and colour in 1m²: a contemplative, place-based study

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Received: 2 January 2021 / Accepted: 21 January 2021 / Published online: 8 July 2021
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Abstract

This essay argues the importance of interdisciplinary, contemplative, place-based pedagogy. The Ecology and Colour in 1m² study has students from the sciences and the arts observe a small quadrat in their local community over several weeks, engaging in both scientific and creative expression. The connection to Aldo Leopold's teaching principles and its relevance during our current screen fatigue pandemic and increasing disconnection from the natural world are outlined. We review contemplative practice in relation to education, such as sit spots or "site-specific" learning. Given the interdisciplinary nature of the Ecology and Colour in 1m² study and aligned with Leopold's emphasis on fostering a personal connection with nature, our paper also includes three narratives and examples of student reflections and visual artwork created during this project.

Résumé

Cet essai fait valoir l'importance d'une pédagogie interdisciplinaire, contemplative, et fondée sur la localité. L'étude "Écologie et couleur sur 1m²" permet aux étudiants des sciences et des arts d'observer un petit quadrat dans leur communauté pendant quelques semaines. Ils s'engagent donc dans une démarche à la fois scientifique et créative. Dans cet essai sont décrits le rapport avec les principes pédagogiques d'Aldo Leopold ainsi que sa pertinence durant la pandémie actuelle, qui cause à la fois une fatigue visuelle causée par les écrans et

Lead Editor: K. Tobin.

This manuscript is part of the special issue Contemplative Inquiry, Wellbeing and Science Education, guest edited by Kenneth Tobin.

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un désengagement croissant d'avec le milieu naturel. Nous passons en revue les pratiques contemplatives liées à l'éducation, telles que les sites d'observation locale ("sit pots") ou l'étude sur place en profondeur. En accord avec la nature interdisciplinaire de l'étude "Écologie et couleur sur 1m²" et l'emphase mise par Leopold sur la création d'un lien personnel avec la nature, notre article comprend trois récits ainsi que des exemples de réflexions d'étudiants et des créations visuelles qui sont émergées de ce projet.

Keywords Interdisciplinary · Ecology · Science education · Place-based · Aldo Leopold

After this course, I will be more appreciative of the beauty of nature and protect the life of plants.

– KPU student reflection, *Colour Theory*

Preamble on interdisciplinary teaching in science

Both the sciences and the arts inform our search for wonder and truth, yet they are often taught as distinctly separate disciplines. Ancient Greeks included literature, philosophy and politics right alongside the arts and sciences. Leonardo da Vinci viewed painting as much a science—through observation, experimentation and repetition—as an art (Roche et al. 2018). Leo Tolstoy compared art and science to the heart and lungs, while philosopher-poet Friedrich Schlegel (1797) wrote, "every art should become science and every science should become art; poetry and philosophy should be unified" (p. 132). Yet today, suggesting that university science students should use poetry or watercolour as well as contemplative practice in their study of ecology might be responded to with disbelief and disregard. This is what we did and the results suggest a creative, immersive and connective avenue of engaging with the natural sciences.

Lee Beavington is an interdisciplinary instructor and learning strategist at Kwantlen Polytechnic University (KPU). His research explores place-based science education and environmental ethics. Amy Huestis is an instructor of drawing and painting at KPU and an interdisciplinary artist whose projects explore storytelling, conservation, art and science. Carson Kever is an instructor in the Department of Biology at KPU. Her research explores topics related to comparative zoology and molecular ecology.

These three authors came together to create this project, inspired to cross both the disciplinary and physical divide between sciences and fine arts on our campus. At KPU Surrey, the biology, chemistry and physics laboratories are in the same building as fine arts. The two faculties share an atrium space, a neutral zone whose outer edges – despite the close proximity – are seldom crossed by those in a foreign discipline. Interdisciplinary projects are encouraged by administration and students both, as this cross-pollination builds community and can lead students on richer, more holistic learning paths.

The most rewarding part was being able to observe the connections animals have to each other and their environment myself rather than reading about it in a textbook.

– KPU student reflection, *Ecology*

This essay will first establish the importance of not simply cross-pollinating the sciences and the arts, but fully re-integrating these disciplines. We will outline the Ecology and Colour in 1m² study (the authors discussed different words to describe Ecology and Colour in 1m², including activity, project and practice; "study" encompasses its immersive and contemplative

nature), its connection to Aldo Leopold's teaching principles and its relevance during our current screen fatigue pandemic (Helander et al. 2020) and increasing disconnection from the natural world (Jickling 2018). Then, we will review contemplative practice in relation to education, such as sit spots or "site-specific" learning. Given the interdisciplinary nature of the Ecology and Colour in 1m² study and aligned with Leopold's emphasis on fostering a personal connection with nature, we also include in the paper three narratives, photography and examples of student reflections and visual artwork created during this project.

The collaboration occurred within second-year ecology science and a fine arts colour theory class. Our primary focus in this paper is on the rewards for post-secondary science learners and educators in using this approach.

Natural philosophers such as Charles Darwin, Margaret Cavendish and Johann Wolfgang von Goethe preceded the term scientist. William Whewell, friend to Darwin, coined the words conductivity, ion and osmosis and also advocated the shift from "man of science" to the gender-neutral *scientist*. This was inclusive of the Scottish polymath Mary Somerville and her transdisciplinary 1834 treatise *On the Connexion of the Physical Sciences* that interwove physics, chemistry, mathematics, astronomy and geology (Cutmore 2019). Early scientists incorporated drawings, descriptive writing and other creative contributions alongside the rational-measurable-objective methodology (i.e., what became known as the Newtonian scientific method).

More recently, Aldo Leopold's writings and sketches became famous in his posthumous book *A Sand County Almanac: And Sketches Here and There*. Leopold was an author, scientist, exemplary professor and a champion of land conservation. His innovative wildlife management and conservation practices, concisely outlined in his seminal "The Land Ethic" essay, "argued for an expansion of the sphere of human ethical concern to include the natural world" (Meine 2015, p. 4). The alignment of his six core teaching principles (Meine 2015) with Ecology and Colour in 1m² is addressed later in this paper.

The ecology and colour in 1m² study

Students from the sciences and fine arts visited a personally chosen one-meter by one-meter site over the course of several weeks (see Fig. 1), deepening their relationship to this place, and engaged in inquiry-based activities through both artistic and scientific lenses. One of the first instructions given: "*You need only find a tree, or a patch of grass.*" Students recorded changes in sound, colour, pattern and weather (and, in some cases, lawn mower), as well as interspecific interactions. Faculty guest lectures, given COVID-19 restrictions, were conducted via prerecorded video. Students from both classes shared their drawings, colour grids, photos, paintings and reflections during a final dual class gathering. Science students learned how to accurately depict their environment and were paired with fine arts students who studied colour theory concepts and learned about ecological interactions at their sites. This allowed the art students deeper immersion into a world of colour and local ecological systems, inspired by select short readings and video instruction by the biology instructors as they developed content for the colour theory classes about ecological concepts such as nutrient cycling, energy flow and interspecific interactions. Students chose their sites and steeped in their individual 1m² quadrats during repeated visits over a month or longer. Young and Gardoqui (2013) offer a succinct summary of this type of learning: "The

Fig. 1 A collage of photographs taken by ecology students at their various quadrats

teaching tool of choice is what Tom Brown Jr. calls the ‘sacred question’, which is actually three questions: ‘What did you observe? What is this telling you? What is this teaching you?’” (p. 50).

This cross-disciplinary collaboration (first implemented in summer 2020) has been taught in three different faculties and has the potential to become part of a larger biology/fine arts curriculum. Amy Huestis ran this project again in fall 2020, using guest video lectures. Lee Beavington ran a modified version for fourth-year education students at Simon Fraser University. The project has been embraced by the university deans, KPU issued a press release and the student-run *The Runner* newspaper published an enthusiastic article (Romero-Afi 2020). Lee Beavington received funding for further study from a MITACS/Simon Fraser University research award and the project was introduced at the Classrooms to Communities Conference, hosted in Prince George, British Columbia in October 2020. The authors plan to teach the class again collaboratively in summer 2021.

Active and arts-based science education

I learned to take time to embrace the beauty in my own backyard. I also learned how science and colour theory correlate with one another, specifically the biological aspects of plant properties and light.

– KPU student reflection, Ecology.

The idea of teaching science with art is not new, but it seems easily forgotten in post-secondary education. Elementary students might draw predictions of the world 100 years from now, or write poetry about octopuses, or learn cell division through dance. This is rare in university. Why? The academy privileges the mind over the body. Students are typically glued to their desks. Lecture and tests dominate post-secondary science education (Stains et. al 2018), despite evidence to the contrary about their effectiveness. Many instructors are not specifically trained on how to teach, other than replicating the way they were taught (i.e., giving lectures and exams). As Lee (2017) explains, “The process of learning to teach remains undervalued, disengaged by and largely invisible within institutions of higher education” (p. 17). She elaborates:

Disciplinary foci ... encourage a stronger relationship with the subject matter than with students. Disciplinarity remains the foundational organizational schema for higher education and the basis for credentialing and expertise. Bodies of knowledge take precedence over activities of engaging knowledge with others. (p. 18)

These are substantial obstacles, beyond the scope of this paper. However, what we *will* do is offer a clear example of a contemplative project for students that has been implemented in science, art and education (though applicable to numerous other) disciplines, which inspires learners to look at the world through a pluralistic lens that includes scientific discernment and artistic expression.

Interdisciplinary teaching enhances higher-order thinking, real-life relevancy, positive attitudes and motivation, and supports “a more holistic view of real-world phenomena” (You 2017, p. 72). Schumacher College in the UK offers an MSc in holistic science that encourages participatory learning and imagination founded in Goethean science. The Sci-Art initiative has a cross-disciplinary residency programme, creates science and technology-based art and hosts regular exhibits. Interdisciplinary arts and sciences programmes are promoted by McMaster University and the University of Windsor, where students cultivate creative process and scientific literacy.

While attending class, I learned that colour theory ... consists of [the] science and art of using colour. It explains how humans perceive colour and how nature has [more] numerous colours than what I thought ... it helped me to understand the relationship between colours and how we perceive them.

– KPU student reflection, Colour Theory.

From the perspective of the fine arts educator, in post-secondary discourse the bringing together of the arts and sciences is becoming more prevalent. Media arts programmes proliferate for interdisciplinary study in art and technology. Often housed within Media Arts departments, art and science education in post-secondary is blended without boundary. The New School of Design/Parsons, McMaster University, CAiiA-Hub at the University of Plymouth and the OI.SE.AU Office for Sentient Architecture/Lip at University of Fortaleza (UNIFOR) in Brazil are all examples of interdisciplinary or transdisciplinary centres of education. These combine disciplines in art and architecture with technology and with

scientific disciplines such as biology and physics. In addition, art and science galleries, exhibitions, programmes and projects are popping up continually in this increased culture of interdisciplinary connectivity.

The virtue of this field of art/science post-secondary teaching is in its fostering of innovation, collaboration and cross-pollination in a world that increasingly blurs lines between disciplines. Distinct categories within fine arts such as painting, sculpture and photography dissolve their boundaries in a twenty-first century field of technological innovation and science. The Colour and Ecology in 1m² study operated in the spirit of this transdisciplinary post-secondary field, creating a space that nurtures the polymath in each of us.

Polymaths and place

We, the authors, found each other as collaborators by following a desire to build cross-disciplinary ties and projects within our academic institution. Online learning in the COVID-19 pandemic added further urgency to this mix—our task, to engage the students with nature and build community across the arts and the sciences and to do this through distance learning. Many famous polymaths led us on this inspired path. Some examples of polymaths through history include Su Song (scientist and artist), Charles Darwin (theologian and biologist), Beatrix Potter (writer and natural scientist) and Vladimir Nabokov (writer and lepidopterist). We elaborate on four other polymaths (or in the case of Kimmerer and Atkins, interdisciplinary practitioners) below.

Jacob Bronowski (1908–1974), scientist and poet, in World War 2 secretly designed mathematical models for effective aerial bombing. He later regretted this and gave a series of lectures on scientific ethics, creativity and truth, summed up in his book *Science and Human Values*, where he said “Science is nothing else than the search to discover unity in the wild variety of nature – or more exactly, in the variety of our experience. Poetry, painting, the arts are the same search ...” (1956, p. 16). Bronowski came to understand what many Indigenous peoples have inherently understood for millennia: respecting the land and the importance of place. When he visited Nagasaki in 1945, the site where the atomic bomb obliterated more than 40,000 (largely civilian) lives, he had a vivid “moment of recognition” (p. 10). The talks for dismantling nuclear weapons should happen *here*, where the implications were deeply embedded in shadow and ruin.

Robin Wall Kimmerer (born 1953), prize-winning author of *Braiding Sweetgrass* and *Gathering Moss*, has gained widespread acclaim as a botanist and writer. Readings by Kimmerer on mutualistic lichen were given to the science and art class for this project. Kimmerer addresses the kinship we have with the natural world, the ecological crises we face and the need for a deeper spiritual connection to the earth. Her research, teaching and writing are embedded in place.

Maria Sybilla Merian (1647–1717), naturalist and scientific illustrator, and Anna Atkins (1799–1871), botanist and photographer, are both examples of women who spent considerable time in outdoor study. As polymaths, they were able to gain a significant place in history in both artistic and scientific contribution. Merian published multiple illustrated botanic volumes on plants and insects, a substantial contribution to her field of entomology. Atkins was the first person to publish a book of photographic images, *Photographs of British Algae: Cyanotype Impressions*. This particular cross-disciplinary area of botany and art has allowed a place in history for many women artists, when other disciplines of painting and sculpture held them out or elided their otherwise meritorious work.

Fig. 2 Watercolour by an ecology student. In her words: “A watercolour outline painting of a grass and buttercup plant. In collaboration with Amy Huestis’s arts class and the concept of colour theory. Every time I return to the same site, I find myself getting excited when I find a new species or something that wasn’t there the time before. It’s as if every time I visit it, it has something new to show me”

The field of botany is historically intertwined with arts practices of drawing and painting and the authors sought a similar re-introduction to the biology students. The discipline of ecology has become increasingly and rightfully data driven and analysis intensive. There is often less focus on purely observational research in the primary literature. However, most hypotheses tested in high-profile ecology journals are drawn from hours of careful observation done by the primary researcher and colleagues. This project gave students the opportunity to practice the observational processes that are at the headwaters of a successful research undertaking.

Biology students were given watercolour paints, paper and brushes and were taught straightforward ways of making direct artistic observation (see Fig. 2). Colour theory students were given teachings on the science and relationships of ecology and considered the various organisms at their sites. All students were given shared readings from biologists David George Haskell and Robin Wall Kimmerer. Colour theory students additionally read about the perception of other organisms and the scientific reasons for colour in the natural world, while ecology students studied nutrient cycles, food webs and plant reproduction.

I also know a lot more about plants and their biology. Although I found studying about the biology of plants quite challenging, especially as a subject matter that has never been in my field of study, but it was helpful to appreciate nature even more and understand the importance of taking care of our environment.

– KPU student reflection, Colour Theory.

Through this Ecology and Colour in 1m² study, students come to know, observe, hear, smell and – perhaps – appreciate a place in their own community. Or as Kimmerer (2013b) advocates, cultivate respect, reciprocity and responsibility toward the community of land.

Leopold's core teaching principles

As Leopold did, the Ecology and Colour in 1m² study incorporates learner-centred curiosity, direct experience and integrating disciplines. Similarly, inspired by Leopold, the GPS ecocache (Beavington and Jewell 2018), a collaboration between biology and geography at KPU, is an activity where students navigate to different sites of ecological interest to answer a question or riddle.

As Leopold ruminated,

Who is the land? We are, but no less the meanest flower that blows. Land ecology discards at the outset the fallacious notion that the wild community is one thing, the human community another.

What are the sciences? Only categories for thinking. Sciences can be taught separately, but they can't be used separately, either for seeing land or doing anything with it.

What is art? Only the drama of the land's workings. (Meine et al. 1999, pp. 275-276)

Meine (2015) is a conservation biologist and Leopold scholar who elucidates the experiential, respectful, interdisciplinary pedagogy promoted by Leopold, which is exceedingly relevant in today's global and educational climate. We will now examine the theoretical and practical context of the Ecology and Colour in 1m² study in more depth, as framed by Leopold's six pedagogical principles.

The cultivation of curiosity and perception

Here, we see a clear connection to the Ecology and Colour in 1m² study, where students sat in their backyards, local parks, or the university campus. Whether among tall trees or lawns and weeds, the contemplative lesson of astute observation and multispecies interconnection remained the same, as students heightened their perception through a series of mindful engagements at a specific site. Following curiosity and using the senses directly to study phenomena is at the heart of place-based education (Humphreys 2018), defined as repeated visits to a local site, with a multidisciplinary approach to learning and experiencing a place, whereby students have agency and make connections to the larger community. This offers "a pathway to wonderment, open to all" (Meine 2015, p. 5). With a creative and sensitive methodology, the context of what is being learned becomes just as important as the content. This is akin to contemplative inquiry, where the learner "approaches the phenomenon delicately and respectfully" (Palmer et al. 2010, p. 95), with gentleness, vulnerability, participation and transformation. In Leopold's (2013) words, "The weeds in a city lot convey the same lesson as the redwoods ... Perception, in short, cannot be purchased with either learned degrees or dollars" (p. 150).

The value of direct, personal, tangible experience

Leopold (2013) worried that "our educational and economic system is headed away from, rather than toward, an intense consciousness of land" (p. 187). Furthering the idea of place-based education is physical outdoor activities where students learn by doing and through lived experience. When this occurs in one's local community, mediated by the senses, where genuine interest is cultivated, the connection can be both immediate and tangible. Phenomenologist David Abram (2011) describes "the body subtly blending itself with

every phenomenon that it perceives” (p. 251) and asks “Can we help our students to carefully translate the quantified abstractions of science into the qualitative language of direct experience[?]” (p. 289). In the Ecology and Colour in 1m² study, this can happen right in students’ backyards. Direct, personal, tangible experience is more likely to be remembered, considered valuable and to be acted upon.

Science education has become increasingly laboratory-based over the past century. Leopold witnessed a disconnection from place, severing “abstract knowledge and living systems” (Meine 2015, p. 5) such that we easily lose sight of the consequences of our actions. Screen-based devices further this divide, mediating our experiences even more during the current screen fatigue pandemic (Jiang 2020). Although screens serve many purposes—communication, creativity, entertainment—they should not displace direct sensorial engagement. Replacing millions of years of evolutionary integration among the natural world with an artificial substitute may serve not only to disconnect us from the places we inhabit and the species with which we share our communities, but may increase a host of common illnesses and disease (Williams 2016).

The capacity for critical thinking and independent judgement

The inquiry-based nature of the Ecology and Colour in 1m² study, where students choose their sites, focus on specific nature subjects and themes that they have discovered and intentionally reflect on their experience, moves in the direction of a science (and other disciplines) that “contributes moral as well as material blessings to the world” (Leopold 2013, p. 134). The value and contributions of other-than-humans may also be considered. Inquiry-based learning helps cultivate critical thinking and independent judgement. Learners that follow their own threads of wonderment, rather than acting as passive receptacles of information, are likely more inclined to ponder, question and devise their own hypotheses and reflect on their own actions toward the biotic community. In speaking of the “ecological conscious”, Leopold (2013) made clear that it is “an affair of the mind as well as the heart” (p. 528). Both scholarship and emotion are of import, since in combination they can help synergize theory and practice, knowledge and action and perception and responsibility.

The need to connect and integrate fields of knowledge

Factual knowledge can be bolstered by a personal story or creative expression. Art takes a primary role here. Songs, films, books, paintings and myriad other media have profound resonance and influence on humans through the exquisite use of storytelling, visuals, poetry and other creative modalities. The climate crisis and the COVID-19 pandemic make this very clear: a transdisciplinary approach is vital to successfully understand, navigate and find resolutions for these crises. As Meine (2015) points out, “Wicked problems persist, when and because, we fail to see connections and relationships” (p. 6). We need geographers to take and analyse ice core samples, climatologists to compare historical and current weather fluctuations, biologists to note how species are adapting (or not) to changing temperatures and distributions, journalists to accurately report what’s happening, teachers to educate the next generation about this issue and why it matters and artists to communicate scientific findings and their ramifications in a way that touches both the mind and the heart. (Similarly, tackling COVID-19 requires the collective effort of virologists, pharmacologists, politicians, scientists, artists, etc.)

Today, true interdisciplinary scholarship is difficult given humankind's extensive knowledge-base, where entire textbooks focus on a single cell type (Henderson 2012). The Ecology and Colour in 1m² study offers a step in this direction. Leopold (2013) wrote that "All the sciences and arts are taught as if they were separate. They are separate only in the classroom" (p. 467). The outside world offers a mosaic of disciplines, from the chemistry of rain and the geology of soil, to the language of birds and the fine art of ferns. Finally, Meine (2015) warns of the

danger when reductionism in science was not coupled with integration, when connections were ignored or neglected. [Leopold] called for 'a reversal of specialization; instead of learning more and more about less and less, we must learn more and more about the whole biotic landscape.' (p. 7)

The need to communicate

In the Ecology and Colour in 1m² study, students are invited to clearly report their findings via several modalities, including photography, drawing, painting, as well as more traditional and referenced academic writing. To be a leader in science, environmentalism and conservation requires "a responsibility for communication" (Meine 2015, p. 7). Clear communication is a core life skill, yet also pertinent for disseminating scientific findings and informed citizenship. Art in its various forms—visual, literary, sonic—can be a direct conduit between concept or idea and the public's mind and heart. Leopold "demanded that knowledge be pursued not just for its own sake, but in service of the public interest" (Meine 2015, p. 7). Science should not simply lead us to power and control, but more so toward wisdom and responsibility. Leopold lamented, "No 'language' adequate for portraying the land mechanism exists in any science or art, save only ecology" (Meine et al. 1999, p. 275), and he held the belief that ecological perception and drama were expressed neither in art nor literature; this has certainly changed, as evidenced by Richard Powers' (2018) Pulitzer-prize winning *The Overstory*, the recent film *Wolfwalkers*, *The Lost Words: Spell Songs* album and countless other art championing ecological literacy. The Ecology and Colour in 1m² study is an expression of Leopold's desire to see ecology science and thinking integrated within culture-at-large.

Keeping the vital link: science and ethics

Science prides itself on being value-free. The hope, by limiting subjectivity, bias and personal belief, is to arrive at a less tainted truth. This stands in contrast to Indigenous science (Cajete 1994) and honourable relations with the land. *Why* we do science must be prioritized over simply *doing* science. Leopold was a staunch advocate of science, yet mapped out the "limitations of science and the dangers of science unmoored from ethics" (Meine 2015, p. 8). He saw ethics that both evolved with and was informed by a community of citizens, yet contended that "Science has no respect for the land as a community of organisms, no concept of man as a fellow passenger in the odyssey of evolution" (Meine et al. 1999, pp. 277–278). This bears a kinship to colonial-settler ideology, where land is seen as a suite of resources to be managed and extracted for explicit human gain. The Ecology and Colour in 1m² study attempts to place the learner within a community of organisms and to foster critical thinking and informed citizenship.

Recognizing the land as colonized is an essential step in current environmental education. The idea of decolonization was ignored during Leopold's era. Yet some parallels exist between his encouraging a respectful and reciprocal relationship with the land and how many Indigenous cultures view the land as teacher, medicine and something sacred and central to our identity; both often witness the land as community. Robin Wall Kimmerer (2012), a member of the Citizen Potawatomi Nation and celebrated author and botanist, emphasizes a "direct participatory relationship between observer and observed" (p. 321). She explains that emotional connections to nature are frowned upon by scientists, yet "Most of us scientists were drawn to our work not by the love of data but by love of the land" (2016, p. 46). Leopold (2013) felt confident that repeated time spent in a place could be transformative: "Once you learn to read the land, I have no fear of what you will do to it, or with it. And I know many pleasant things it will do to you" (p. 523). Here, the biotic landscape takes on the role of listener, muse and teacher.

Contemplative science and art: sites and sit spots

When we started work on our ecology pieces and I was trying to locate a suitable site, I was a bit confused about what this had to do with colour theory. But when I opened my mind, I found myself becoming more interested in the project and beginning to enjoy it. I went outside and just listened and whenever I returned to my site, I discovered new perspectives and found the inspiration to ask questions about the world around me.

– KPU student reflection, *Colour Theory*

Many outdoor educators incorporate contemplative practice into their teaching. Jon Young refers to "sit spots," (Young et al. 2013) or in fine arts "site specific studies." In our case, the students studied quadrats, following the example and readings of biologist David George Haskell in his book, *The Forest Unseen*. He visited the same, randomly chosen 1 m x 1 m section of old growth in southeast Tennessee over the course of a year, using the mandala as his guiding metaphor of observation and impermanence. As Haskell (2013) explains,

My rules at the mandala are simple: visit often, watching a year circle past; be quiet, keep disturbance to a minimum; no killing, nor removal of creatures, no digging in or crawling over the mandala. The occasional thoughtful touch is enough. (p. xiv)

Leonardo da Vinci was preoccupied with "learning 'how to see' and that Nature itself is the best book from which to learn" (Roche et al. 2018, p. 15). Further, his exploration of visual arts led him to question perception and sensory experience. Haskell (2020) offers learners invitations for mindful, sensory connection with nature, yet outdoor contemplative practice facilitated in science and art teaching is seldom seen in post-secondary. The reasons are numerous: most classrooms and laboratories occur indoors, instructors are unfamiliar (or uncomfortable) with facilitating mindfulness or other contemplative activities, there is too much content to cover and lecture (specifically in STEM fields) predominates.

Young et al. (2013) speak of the "sphere of awareness" and "sphere of disturbance" (p. 64). When our perception and awareness exceed our disruption and disturbance, our presence shifts from scattering wildlife to sharing their space. A goal of the Ecology and Colour in 1m² study is to have students cultivate awareness and limit disturbance, through

sensory expansion, contemplative practice and building a reverent relationship with a specific place.

During a webinar, one of the authors (Lee Beavington) asked Haskell for creative ways to learn ecology at a small, specific site. He responded:

the invitation is rooted in the contemplative practices of the religious and philosophical traditions around the world, whether it's Buddhism or Taoism or even parts of Christianity, the contemplative dimension is there. And what I've done, say, in *The Forest Unseen*, is apply that to ecological observation. What is contemplative practice? Returning again and again to the same word, or observation of breath, or painting, or small patch of forest, without expectation as much as possible, with open senses ... returning again and again to open senses in a particular place is the first step. Then the step and whether it's in what we would call arts or sciences, is then to ask how that connects to our curiosity and imagination. What questions emerge from this? What kinds of relationships are we perceiving here and where might that take us? (Emergence Magazine 2020, 54:11)

Such slowing down and discerning the fine details are pertinent for both the artist and the scientist. Contemplative approaches to education are not only beneficial to students' mental health (Kaplan 2001) and their ability to focus (Kaplan 1995), but can also boost academic performance (Galante et al. 2020). Attuning our focus, making accurate observations, and connecting patterns and unexpected forms are vital in many fields, not just the life sciences and fine arts.

During the COVID-19 pandemic, students spent long hours indoors, often working alone in their rooms in online learning scenarios. The lack of face-to-face contact and social interaction can contribute to mental health challenges. University of Toronto student, Rahat Charyyev, said to the CBC, "Because you spend the whole day inside the house, whether it's dark [or] whether it's light outside, it doesn't matter... it's kind of like you really lose track of time zones, what day it is. And, it just feels like a never-ending cycle, like a hamster wheel" (Wong 2020). Students who work with quadrats in this project spend many hours, instead, working outside in contemplation and active participation with the natural world, the screen and keyboard replaced with pen, paintbrush and the immediate senses.

This offered both students and instructors an opportunity to work with Nature as teacher. What unfolded for the science students in their quadrats was a deeper gaze into the science of relationships. From the visual, sonic, olfactory and textual landscapes emerged a visceral connection to their study site, a prolonged practice in observation and a heightened curiosity (all part of the bedrock of the scientific method) that led to questions regarding interspecific interactions, invasive species and human disturbance. They wondered why a particular ant species was often found near the extrafloral nectaries of the cherry tree, what the squirrel's tail flick meant and how fast dandelions produced and lost their seeds (akin to the spatial-temporal focus of Goethean science; see Rose 2021 in this issue). Arts-based engagement (see Fig. 3), such as drawing, photography and watercolour, offered a more creative expression that led to recognizing patterns, colours and shapes germane to the local ecological interconnections.

What unfolded for the colour theory students was the observation and recording of the myriad colours in nature. The complexity and changing world of colour in their quadrat far outshone what would have been available to see or observe in their rooms, or conjured through imaginative exercises. Scientific information validated and strengthened their observations and led them down paths of their own curiosity. The "gray thing" became the

Fig. 3 Examples of ecology students' observations at their quadrats. Note, in the lower left, the ant on the cherry tree

complex colour study of the fly. The “all green” world became one rich in a multitude of colours, shades and tones.

I was totally an outsider to paint and colour theory. However, color is everywhere. It is the language of nature. The experience of study at the site was an important turning point for me. It was the first time for me to actually feel nature. I found the color of nature is harmonious and intoxicating. I started to put my attention to the color of nature. The dead leaves are yellow, brown and red. The lichen is green, grass green and dark green ... Colors can speak. If you walk on a street and glimpse a dead leaf. The silent yellow is talking to you: ‘The autumn is coming’

– KPU student reflection, *Colour Theory*.

During this backyard solitary contemplation, students appreciated the communal connection, of knowing that dozens of other students were also sitting at their quadrats. This feeling of individual but common action built healthy minds and hearts and a deeper meaning and relevance, since this immersion occurred in a place both familiar and close to

home. The sharing the students did allowed them to express their care for their own assignments, for lived experience and for nature as a whole.

Teaching online, sequestered by COVID-19, underlies the need for community interaction and campus-driven connection, where students of different disciplines cross paths in the courtyard, cafeteria, or library and meet socially. This project offered (albeit remotely, in this iteration) community building—fine arts students met biology students, did shared readings and worked with a common purpose. There is both support and safety for the student who sits in her individual quadrat, making scientific observations and colour studies, to know that others are doing the same.

Storytelling and place

In this final section, we shift to narratives that emphasize the importance of immersive, outdoor, place-based experiences that are nonlinear and ultimately self-perpetuating. Carson and Lee composed narratives based on their own experiences, while Amy took inspiration from a student's experience. The context and importance are embedded within each piece.

Reciprocity to land (Kimmerer 2013a) and other Indigenous themes of relationship to place, ethnobotany, and learning from the land were important to the Ecology and Colour in 1m² study. Our university resides on the traditional, unceded territories of the Kwantlen, Musqueam, Katzie, Semiahmoo, Tsawwassen, Qayqayt and Kwikwetlem peoples and our five campuses spread through the valley and estuary of the Fraser River, a key ecological site in the Canadian West and the place of a multitude of scientific studies. Given that only 30% of vital ecological areas of the Fraser River Estuary remain protected, there is an urgency in teaching our students the importance of the place in which they live. The Ecology and Colour in 1m² study cultivated not only critical thinking and scientific knowledge, but also empathy, community and appreciation for the land.

Watching eyes open (written by Amy Huestis)

In this class, I got a chance to learn about nature and the infinite colours I found there. I was always avoiding and not interested in painting nature ... because I thought it only consisted of green colours. On the other hand, the advantage of taking this class gave me the opportunity to discover precious and beautiful colours in nature.

– KPU student reflection, *Colour Theory*.

The idea of *Nature as teacher* unfolded in front of me as an educator in this project of Ecology and Colour in 1m². What I wanted the students to learn—the complexity of colour, the respect and appreciation of the natural world, the empathy for other organisms—was in a sense taught to them at their sites. Providing them the structure to go there and to do this as a group but individually meant providing them an open opportunity for curiosity and inquiry on their own.

One student in particular, let's call her Mary, needed to be coaxed outside. In a phone meeting, Mary argued that she could make her studies through photographs indoors without direct observation, showing a distinct aversion to sitting outside. Explaining the idea of observation of intricate colours to Mary, she exclaimed, "Everything out there is green!"

Over the many weeks of Mary's observation, what unfolded in her studies was almost unreal. Mary's final studies showed extraordinary inspiration, complexity and detail in colour mixing. The natural world taught her of its infinite ways in changing shades and harmonies.

Immersion in science research (written by Carson Kever)

As an instructor what initially drew me to this project was the opportunity for students to fully immerse themselves in an environment and to therein discern ecological interactions. Furthermore, the process of immersion was connected to their assessment. We invited students to go and immerse themselves in nature and think about ecology.

In my own experience as a biologist, there is no better way to come to terms with a tough concept or process in biology than to live and breathe that process as if there was nothing else in the world of significant consequence. I have only had that opportunity on a handful of occasions and these instances have occurred over weeks and months of deep contemplation. I have included two examples below.

My first experience with this process was as an undergraduate at University of California, Davis. I was fortunate enough to have been hired as a research assistant in a laboratory that primarily focused on marine ecology using a molecular approach, which basically means lots of PCR. PCR stands for Polymerase Chain Reaction, which is a molecular reaction that results in many copies of DNA that researchers can then examine in an ecological context. To physically do PCR is very repetitive, and often boring, but to fully understand PCR is a much more complex proposition. For me, it was hours and hours of sitting at the lab bench dutifully pipetting small volumes of liquids from test tube to test tube and contemplating what I was doing (sometimes subconsciously) that gave me an intricate understanding of the process of PCR.

The second example centers around the geography of the Australian Coastline. As a graduate student, part of my dissertation research involved visiting coastal locations throughout Australia. I was on the hunt for a small sample of tissue from Echinoderms (sea stars) that lived in the tide pools. I spent months driving through Australia and then sitting on beaches, thinking about where I was and how one location might relate to another location in terms of tides, currents and the structure of the coastline. From this experience, I gained a vivid understanding of the coastal processes that govern Australian near-shore environments. That understanding provided bedrock for many of the conclusions drawn in my dissertation research.

Return to Fern Alley (written by Lee Beavington)

Across the ditch, a hint of a southerly trail wends into temperate rainforest. Blind to this pocket of wonder, I walked by hundreds of times, deeming this a deer path. More than two thousand of these ungulates reside on Mayne Island and less than a thousand permanent human residents. Yet when I finally abandoned the paved road for this trail less travelled, I stepped into a new world.

Outside this place, a path of robust deer fern hugs the roadside ditch, the densest population of *Blechnum spicant* on the island, which leads me into forest (see Fig. 4). The threshold is bordered by two dead Douglas-firs. To the left, a toppled giant, its huge

Fig. 4 Entrance to Fern Alley

tangle of unmoored roots holding a living wall of cascading sword fern. On the right, a ten-foot hollowed stump with huge shards of furrowed bark as thick as my chest. Salal and huckleberry explode from this stump's heart like fireworks, death begetting life, a primal rule of forest ecology.

I pass these two sentinels, apart yet somehow united. Beyond the shadow of these giants lies a sea of rich-green fronds. The path is flooded with ferns.

Deer ferns possess two types of fronds. The most prominent is the sterile, which spread their elegant and evergreen leaflets like a starburst in all directions, whereas the slender fertile fronds stand erect, verdant peacock feathers black with reproductive spores. They will wilt after summer's heat. The presence of deer fern indicates I am close to water, under shade and stepping on nutrient-leached soil. Some Indigenous peoples ate these fern leaflets as a hunger and thirst suppressant during long hunts.

So tightly packed are the deer ferns that their symmetric frond photosynthesizers overlap like competing sawfish. Even with a careful tread, it is hard to avoid stepping on a seemingly delicate frond. I remind myself that these resilient fern's ancestors have existed for hundreds of millions of years.

The uneven path, rutted by rain and hoof, dips around the towering stump. I'm surprised when, after circumventing the Douglas-firs, a strikingly linear corridor cuts uphill. A single power line runs overhead, illuminating the source of this mysterious straightness. Is this someone's cabin or mini-power station? I've never seen anyone here. When I check a Mayne Island property map, this appears to be an easement for hydro or water treatment.

I bring my kids the next day and the next. During the 2020 pandemic, this becomes a regular routine. Aged three and seven, my daughter and son begin to explore every nook and cranny of Fern Alley. My son finds an alternate entrance, a small creek and, after clambering up a low hill, he proclaims: "This is my sit spot for the day!" My daughter loses her boot in the mud, scales a precipice twice her height and asks me why I like ferns. "Well," I say, putting on that fatherly tone to indicate I have something wise to say while I make it up on the spot, "ferns have a simple beauty and symmetry. They hide

Fig. 5 A collage of photographs taken at Fern Alley

wonders under their fronds”—I lift one to reveal a white spider—“and the dinosaurs used to munch on them!”.

This small pocket of forest holds endless learning possibilities that shift with the seasons (see Fig. 5). In the spring, I watched, day by day, the slow reveal of countless fiddleheads unfurling their month-long secrets, while my daughter decided to tread barefoot, quickly discerning which plant parts were soft underfoot and which were sharp. In summer I photographed the criss-crossing fronds, while my son taught his sister how to climb. Autumn brought the study of leaf abscission and senescence, in the roadmaps drawn in yellow, orange and red on the blades of salal leaves; my son built dams in the mud and clay, adapting his construction to the little creek’s altered flow. Winter turned the entire fern trail into a stream and my daughter and I waded to find the source of this watery influx.

“Fern Alley turned into a river,” she exclaimed. “I can’t believe it!”

I never gave them a lesson here. Whether for my preschool-aged daughter, or her father completing a PhD, the *place* was the teacher. In this place, Ecology students could learn nutrient cycling, soil formation and erosion, water chemistry, biodiversity, decomposition and food webs and the holistic interrelation of all of these topics.

To write this narrative, I lingered at the entrance of Fern Alley, between the guardian Douglas-firs. As my senses soaked in the loamy upturned earth and a raven *kraad* to her mate, who returned the call from afar, it suddenly hit me. Here, in the low pit between the stump and log, was where the root ball once intermingled with the earth. These were not two trees, but one. I was standing where this single, ancient giant once stood. By its act of dying, this fir opened a path into wonder.

Acknowledgement This work was supported by Mitacs through the Mitacs Research Training Award.

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Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

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