Versatile Genius: A Case Study Intersecting Math, Science, Art, and California's National Parks

Leslie Love Stone
Leslie Love Stone Studio
804 Sycamore Canyon Rd.
Paso Robles, CA 93446
leslielovestone@gmail.com

Christopher S. Brownell
Fresno Pacific University
1717 S. Chestnut Ave.
Fresno, CA 93702
chris.brownell@fresno.edu

Abstract

The advantages of a polymathic approach are remarkable: it cross-pollinates ideas, encourages creativity, defines new methodologies, and solves complex problems. Interdisciplinarity also presents challenges. In this case study, which intersects math, science, and art, we describe how a project can benefit from a respect for the rigors, focus, and coherence of multiple disciplines. Although most interdisciplinary projects are dominated by a particular field (in point of view, level of expertise, and disciplinary significance), this does not preclude a project's author-maker from complying with the standards of the component disciplines. The author-maker of the project described in this case study is a professional artist who holds a decidedly mathematical point of view. The art, which is created with a high degree of disciplinary proficiency, predominates; and although elementary, the math is no less legitimate.

Introduction

There was a time in human history when to be well-read or "renaissance" meant that you had read or mastered a wide variety of works. In fact, it was possible to have read all significant published works in a field just a few short centuries ago. Those who possessed this “versatile genius” could make contributions in a wide variety of fields of study. Today, this idea of reading every published work is a literal impossibility as global information grows exponentially. This should not, however, prevent us from the pursuit of broad methods of approach when it comes to reality, truth, or expression. A first step in this process is to respect the disciplines in a variety of fields. Our purpose in this paper is to make the case that this respect can deliver rich and intricate understandings that also communicate complex ideas within and across the two disciplines of mathematics and art.

We think of these pursuits as polymathic, as they incorporate elements of both disciplines and strive to keep them in constant tension with each other. We present here a case study of one such polymathic art project entitled, *The Last of the Mohicans* ∩ *California National Parks* ∩ *Blue-Green-Brown*. We would like to place this series of paintings as one that holds high a respect for both mathematical and artistic disciplines.

Our position of contrast stems from the question, “If an artist were to look at a carefully rendered and professionally framed zoom on the Mandelbrot Set, would she see it as art?” This question needs to be addressed in mathematical art exhibitions and in conference. Most artists would agree that said zoom would be a beautiful documentation of the phenomena, and the choice of coloring, orientation, and perspective add to that sense of beauty. But neither beauty nor documentation are an artist’s primary objective within his or her discipline. There are commonalities between disciplines that ought to be explored and actively integrated in our work as mathematicians who intend to create art.

Part of the issue with this approach is that the rigors, focus, and coherence of the artistic discipline are not as well known or understood by those in nonart fields. The scientific method, a sense of

mathematical methodology, and other more quantitative methods of inquiry and communication are held in primacy in much of our schooling, speaking from a decidedly American perspective. How much time, effort, or attention is given to the artistic method, which involves concepts of composition via elements (e.g., line, shape, color, texture) and principles (e.g., repetition, balance, dominance) of design, both with an expectation of dialogue with past and contemporary art. Without these concepts (and several others), a work falls short of the art world's definition of fine art. The integration of art in science, technology, engineering, and mathematics (STEAM) is a polymathic goal we support. Understanding the conventions and disciplines of art will strengthen the artistic qualities of mathematical art. Our intent herein is to point out some ways in which mathematical principles of discovery, description, and sense-making run parallel to the similar principles in art.

The Project

Background. This project comprised a series of artworks created by conceptual painter Leslie Love Stone and is based, in part, on California's nine National Parks. The paintings have been structured in a way consistent with the artist's current practice, which focuses on the connections and assumptions we make within an imposed structure and how we develop theories predicated on imperfect information [6].

Stone uses geometric shapes and her own digit representation system to abstract and reanimate numerical data; she uses form and composition to explore the space between what we know and what we don't know. With colors ranging from Death Valley's muted neutrals to Lassen Volcanic's stunning blues and greens, this series of paintings is a seductive example of artistic style—California landscape meets California hard edge.

Methodology. The project began in June 2015, took a year and a half to complete, and culminated in the exhibition of nine paintings at the San Luis Obispo Museum of Art (SLOMA) in San Luis Obispo, California, from November 18, 2016 through January 29, 2017, shown in Figure 1. A multi-phased process was implemented and included: (a) determining compositional components and configurations, (b) interviewing consultants and co-investigators, (c) applying to the National Park Service for specimen collection permits, (d) in-field palette collection, (e) in-studio palette development, and (f) artmaking.

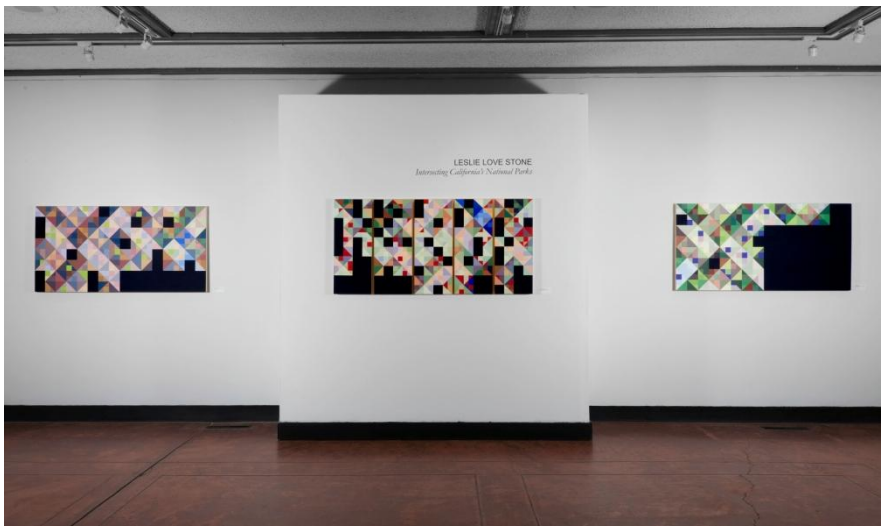

Figure 1: *Partial gallery view of the National Parks project paintings, SLOMA.*

Consultants and co-investigators. Stone met with faculty and staff at California Polytechnic State University's Botany, Soil Science, and GIS Data Mapping departments in San Luis Obispo to discuss the parameters of the project including plants indigenous to California's National Parks and their seasonality, scientific protocols for specimen collection, how soil scientists use art professor Albert H. Munsell's color system to identify types of soil, and GIS mapping data denoting the percentages of precipitation, visible vegetation, and visible soil as shown in Table 1.

Table 1. *California National Parks by Area and Percentage of Precipitation, Visible Vegetation, and Soil*

National Park	Area *(acres)*	Precipitation	Visible Vegetation	Visible Soil
Pinnacles	26,606	4%	63%	33%
Lassen Volcanic	106,452	20%	68%	12%
Redwood	139,000	22%	75%	4%
Channel Islands	249,561	4%	43%	53%
Sequoia	404,064	10%	61%	29%
Kings Canyon	461,901	11%	44%	45%
Yosemite	748,036	14%	58%	28%
Joshua Tree	790,636	2%	7%	91%
Death Valley	3,373,063	1%	5%	94%

In the original scope of this project, the artist intended to collect actual plant and soil samples from which a palette would be created. Because specimen collection permits were denied in eight of the nine National Parks (see Issues and Barriers), an observational, in-field color-matching process was devised to replace the notion of bringing plants and soils back to the artist's studio for palette development. Pinnacles National Park did approve Stone's request to collect specimens, which were obtained during her visit in March 2016 and accessioned into the Cal Poly Herbarium's permanent archives.

In-field site visits. Palettes were collected from a single site in each Park, with the latitude and longitude noted for each. Dates for in-field visits were determined by Park Superintendents (in the case of Pinnacles National Park), Park alerts, weather, and completion of in-studio preparation.

Themes and structures. Like an intricately constructed theorem, Stone's paintings use facts woven together with previously established statements and logic to demonstrate that we seek understanding through pattern even in the absence of perfect information. The artist uses a metaphorical set theory, "artistic axioms" like Malevich's black square, and her own digit representation system to demonstrate that we all unconsciously translate what we know into something we can understand.

While the National Parks project content has its own specific implications and meanings, the series of paintings created for this project rests on the same wider themes—how we process and understand information—as Stone's other work and functions with the same structure, materials, and process.

Variation on Venn's diagram. Each of Stone's paintings seeks to describe intersections of three metaphorical sets: a set of numbers; a physical, typically organic, object; and the meaning of the painting's colors. Although the colors derive from and depict the object, the symbolism associated with individual colors is important enough to add a third set and further layers of meaning, visualized in Figure 2. The color blue, for example, has a variety of contextual definitions ranging from happy to melancholy to profane.

Like a Venn diagram, each painting reveals the artist's perception of the overlap of its elements, and suggests that connection may be found, as shown in Figure 3. In these paintings, (a) number sets derive from the novel *The Last of the Mohicans* by James Fenimore Cooper; (b) the objects and source of the

palette for each painting are California's nine National Parks; and (c) blue, green, and brown, which represent in accurate proportion precipitation, visible vegetation, and visible soil, as shown in Table 1. Painting titles are written in mathematical notation to cite the specific elements intersected, always in the same order: data, object, color. In this series, the paintings are entitled *The Last of the Mohicans* ∩ *[National Park]* ∩ *Blue-Green-Brown*, with one painting for each of the nine California National Parks.

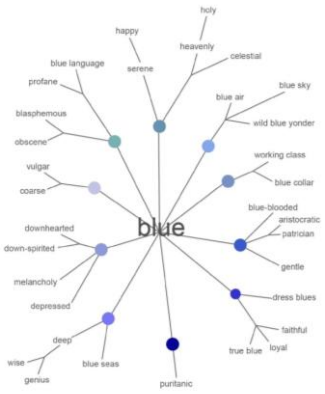

Figure 2: *Tree graph of the various meanings associated with the color blue.*

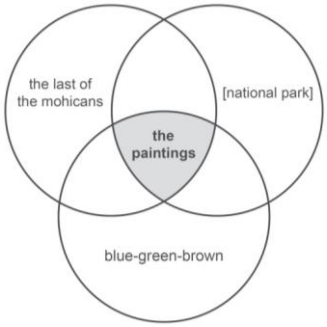

Figure 3: *Venn diagram for the National Parks project paintings.*

Figure 4: *Illustration of the "bucket" concept for Stone's digit representation system.*

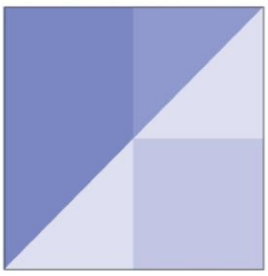

Figure 5: *An example of how the number six might appear.*

Number representation. Stone uses her own digit representation system to expand the boundaries of how we convey data—to integrate multiple layers of information beyond the counting function of numbers. Each square is one digit. Each square is divided on the diagonal with a dark side and a light side. The dark side tells you which of three "buckets" the number falls into: 1-2-3, 4-5-6, or 7-8-9; shown in Figure 4. The light side tells you whether the number is first, second, or third in the bucket. In this, Stone employs a one-to-one correspondence (bijective mapping) between individual members of her buckets and the set of digits. For example, if the dark side has two segments (indicating bucket 4-5-6) and the light side has three (indicating the third number in the bucket), the number is six; shown in Figure 5. In a four-by-four collection of squares, the top and bottom rows each encode two digits. The leftmost digit in any row is then multiplied by 10^1 or inserted into the 10^1 place, and the right most digit configuration is multiplied by 10^0 or merely retains its face-value. This mapping accomplishes the creation of a two-digit number. Additionally, zero is indicated by black (or the absence of added color) and can occur in either a "tens place" or a "units place." Furthermore, segments painted in a nonrelated color add 100 to the two-digit number; shown in Figure 7. Looking at the leftmost four-by-four array in

Figure 7, we see both the use of the black square to create a units digit of 0 and the use of three violet (neither blue, green, nor brown) segments (one above the diagonal of left, one below the diagonal of the left, and one below the diagonal of the right) are used to adjust the values of the digits to represent the desired three-digit number.

Figure 6: *The Last of the Mohicans ∩ Yosemite National Park ∩ Blue-Green-Brown, which presents the John Muir quote, "Take a course in good water and air; and in the eternal youth of Nature you may renew your own. Go quietly, alone; no harm will befall you." If the viewer had access to the cipher's key and knew how to read the numbers, the viewer would be able to decipher the painting's message.*

Figure 7: *Detail of The Last of the Mohicans ∩ Yosemite National Park ∩ Blue-Green-Brown showing two pairs of numbers. In the first four-square block are 40, 353; in the second are 92, 03.*

Embedded book cipher. A simple book cipher (sometimes known as codebook encipherment) is used to encode worded messages by replacing them with the numerical locations of the words. The cipher's key is always the first element in the painting's three sets. In the National Parks series, all paintings use the same key, which is *The Last of the Mohicans*. Each four-square block contains a pair of numbers (page number, word count) that represent one word in the cipher. The artist asks, Do we believe that true meaning is always hidden or is it hidden because we don't have the key? These paintings contain quotes from early environmentalists like John Muir, Henry David Thoreau, and Theodore Roosevelt. Length of quote determines how much of the surface is painted in the Park's palette. Although there is not a proportional relationship between painted surface and size of Park, the longest quote was assigned to the

largest Park, the shortest quote to the smallest Park, and so on. The artist's copy of the codebook and a description of this encipherment were on display during exhibition, enhancing viewer experience.

Form and content. Artists, art critics, and art historians typically describe a work of art in terms of its form—the style, technique, media—and content or meaning [5]. These paintings are presented on wood panels that are 30″ high by 60″ wide, except for the Channel Islands painting, which comprises five panels to occupy the same space, acting as metaphor for the five islands. The palette hues, including black, are mixed from red, yellow, and blue only and created with Flashe, which is a highly pigmented, water-based vinyl paint with a powdery finish. White is added to gradate the values of each hue. Stone uses design elements like color, space, and shape to abstract content, reanimate data, and emphasize design principles such as repetitive pattern, movement, and asymmetrical balance, as shown in Figure 6.

Although content is viewed differently, there are instances where formal choices become part of the content. For example, Stone works on wood panels, leaving the cradles unpainted, to remind viewers that no matter how synthesized or sterile the data may seem, they always rest on organic phenomena.

The paintings begin with a black surface, suggesting Malevich's *Black Square*, and its zero point of painting. Because black is made by combining the three primaries, the building blocks for an infinite number of colors is contained in the mixture; profound possibility is coded into each painting. Rearranging primary elements in a gridded structure references Piet Mondrian's lozenge paintings to engage viewers in a broader conversation with De Stijl, Cubism, and Minimalism ideals. Putting complex content into nonrepresentational works, thereby bridging Minimalism and Conceptual Art, expands the dialogue to include Sol LeWitt.

Although the paintings have been presented in landscape format as appropriate for a discussion on the environment, the panels have no fixed position. Like a world map, orientation is not important; North America maintains its position in relation to the other continents regardless of how the map is hung. The paintings can be read from any direction, making each point of view valid.

A possible interpretation. In order to have a discussion about a particular aspect of environmental stewardship, the artist has intersected *The Last of the Mohicans*, California's National Parks, and the meanings of blue, green, and brown. The protagonist in *The Last of the Mohicans*, Natty Bumppo, aka Hawkeye, is a white man who has been raised by Delaware Indians. A kind of colonial hybrid, Hawkeye speaks two languages, understands his European heritage, and lives off the land with deep respect for Nature. Antagonist Colonel Munro expects the world, including the Colonials, the Indians, and the Environment, to adapt to the Empire and British sensibilities. Colonel Munro is ultimately proved ineffectual [3]. Since 1916, the National Park Service "preserves unimpaired the natural and cultural resources and values of the National Park System for the enjoyment, education, and inspiration of this and future generations" [4]. The point at which book and Park cross asks the viewer to consider a differently configured world. Overlay that with the meanings commonly assigned to blue, green, and brown—stability, growth, and security—and we must question whether or not these meanings are sustainable where man is more consumer than conservationist.

When we adapt to Nature's rhythms and routines, when we allow it to amaze and transform us, principles of conservation and sustainability for soil, vegetation, water, and wildlife become de rigueur. John Muir described interdependence like this: "When we try to pick out anything by itself, we find it connected to everything else in the universe." Our connectedness makes it clear that a system in balance benefits everyone. What if the entire country were a National Park and we had to abide by Park Service rules? What if we never drove over 25 miles per hour? What if discharging firearms were illegal? What if all animals were considered wild? *Imagine...above us only sky*.

Like an essay, the series covers its topic, with each painting serving as supporting argument to the artist's thesis that in order to cherish and preserve Nature, we must connect with it. In fact, our very character is defined by our relationship to the environment.

Issues and Barriers

What Is Art? Art has rules. The problem in defining them is that the iconoclastic nature of creativity depends on breaking rules. Among artists and art educators, critics, and historians, definitions vary, which has resulted in volumes of heated discussion. One school of thought asserts that if an artist makes it or hangs it in a gallery, it's art. Of course, this interpretation relegates art to subjective classification determined by art world insiders. Conversely, why an artist makes work, an artist's *intent* (e.g., catharsis, emotional expression, intellectual engagement, social activism) is often part of the content, but has been deemed irrelevant by Wimsatt and Monroe Beardsley in their essay, "The Intentional Fallacy" [9]. German philosopher Theodor Adorno wrote in his book *Aesthetic Theory*, "It is self-evident that nothing concerning art is self-evident." So, how do we know whether something is art or documentation?

As previously stated and typically accepted, art is form and content. Makers use line, shape, and color to move the eye through balance, repetition, and dominance. Visual artists communicate ideas with images rather than words and both representational and nonrepresentational art uses symbolism and metaphor to convey meaning. Content is message, form is medium—what and how. Additionally, the art world includes culturally literate dialogue among contemporary and past works. According to the *Stanford Encyclopedia of Philosophy* [7], American art critic and philosopher Arthur Danto defines art this way: "Something is a work of art if and only if it has a subject about which it projects some attitude or point of view (has style) by means of rhetorical ellipsis (usually metaphorical) which ellipsis engages audience participation in filling in what is missing and where the work in question and the interpretations thereof require an art historical context."

American statistician and pioneer in the field of data visualization Edward Tufte describes in his book *Beautiful Evidence* that the theory and practice of analytical design is about how data and evidence can turn into explanation [8]. The practice of presenting information in a way that encourages understanding is crucial, but it isn't art. Mathematical visualization like the Mandelbrot Set, regardless of its aesthetic appeal, is documentation because it lacks artist expression and contextual dialogue.

Barriers to interdisciplinarity. When a truly interdisciplinary approach is used for a project, respect is given to the rigors, focus, and coherence of the component disciplines even though they may sometimes seem at odds. Traditional viewpoints are pitted against each other as colleagues try to understand and define the scope of a project that combines multiple schools of thought. Boundaries are crossed. In our case study project, the artist applied for, and was denied in all but one Park, a permit to collect plant and soil specimens.

With daily sieges on the National Park Service's mission to "preserve unimpaired" the country's natural resources, it is understandable that Park employees charged with reviewing and approving permit applications must be strict in their interpretation of what is an acceptable project. Different perspectives on concepts are not always easily overcome; often, in fact, an artist’s perspective may seem entirely contrary to a scientist's or mathematician’s and vice versa. Contrary aesthetics clash, isomorphic words with nuanced meanings that can only be understood from one or the other’s frame of reference present challenges to communication all along the way.

Conclusions

As described above, art is defined in a way that presents a rich opportunity for invention, discussion, and problem-solving. This is not unlike how William Byers describes what mathematics is in his wonderful book, *How Mathematicians Think: Using Ambiguity, Contradiction & Paradox to Create Mathematics.* Therein he describes the mathematician’s work to be swimming in ambiguity, which breeds perturbation, which yields insight and ultimately some amount of resolution of the ambiguity. The creative work of a

mathematician is often done at this crux. Through a shifting of the mind's eye from perspective to perspective, a problem will be solved in the mathematician's mind. This is often done in internal conversation with former mathematical understandings, yet it is the genesis of new, previously unseen truths.

So it is with art, an artist settles into her studio or even within her mind and dives into the ambiguous and poorly defined space that is her desired point. This case study is no exception; in fact, it is a prime example of how mathematics and art must acknowledge each other's legitimacy and intersections. Although the sets chosen from the beginning may not be well defined in a strong mathematical manner, they present rules for inclusion and exclusion that are clear. Drawing upon the notion of intersection of sets is the artist's attempt at swimming in the ambiguity inherent in the situation; it is this act that is the creative spark. Her choice to encode messages to the truly curious observer connects us to the previously unseen truths that she brought to life in her mind. Her artistic disciplines kept her hemmed in by technique, process, and conversation with former works—fundamental aspects of the project that make this a work of art. The use of metaphor, ambiguity, logic, and cryptography make it a work of mathematics.

For mathematical art to be recognized as such by both the mathematics and art communities, it must be subjected to both sets of disciplines. This thought should inspire its practitioners to versatility, greater genius, and new ways to solve problems.

Acknowledgements

We thank the following colleagues for providing insight and expertise that greatly assisted this project and the completion of our paper: Taylor Chase, Artist/Photographer; Brent Johnson, Chief/Integrated Cultural and Natural Resources, Pinnacles National Park; Paul Johnson, Wildlife Biologist, Pinnacles National Park; Karen Kile, Executive Director, San Luis Obispo Museum of Art; Steve Pauls, Ph.D., Fresno Pacific University; Ruta Saliklis, Curator and Director of Exhibitions, San Luis Obispo Museum; Craig Stubler, Instructional Support Technician, Natural Resources Management and Environmental Sciences, California Polytechnic State University, San Luis Obispo; Russ White, M.S., Numeric and Spatial Data Specialist, Robert E. Kennedy Library, California Polytechnic State University, San Luis Obispo; Patch Wright, MFA, Artist; Jenn Yost, Ph.D., Professor/Biological Sciences (Botany) and Director/Robert F. Hoover Herbarium, California Polytechnic State University, San Luis Obispo.

References

[1] Adorno, Theodor W. *Aesthetic Theory*. (1970) University of Minnesota Press. 1997.
[2] Byers, William. *How Mathematicians Think: Using Ambiguity, Contradiction, and Paradox to Create Mathematics*. 2007. Princeton Press.
[3] Cooper, James Fenimore. *The Last of the Mohicans*. George Macy Companies. 1932.
[4] National Park Service. Retrieved from `https://www.nps.gov`. 2017.
[5] Sayre, Henry M. *A World of Art*. New Jersey: Pearson Education, Inc. 2012.
[6] Stone, Leslie Love. Retrieved from `https://www.leslielovestone.com`. 2016.
[7] Adajian, Thomas, "The Definition of Art", *The Stanford Encyclopedia of Philosophy.* Summer 2016 Edition. Edward N. Zalta, editor. Retrieved from `https://plato.stanford.edu/archives/sum2016/entries/art-definition`.
[8] Tufte, Edward. *Beautiful Evidence*. 2006.
[9] Wimsatt, William K. Jr. and Monroe C. Beardsley. "The Intentional Fallacy." 1946, revised 1954.