Collaborations in Art and Science: Disciplinary entanglements and public participation

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Abstract

This paper examines the resurgence of interdisciplinary research that bridges art and science. It underscores the ways computational advancements and the pressing demands posed by climate change are driving the revival. It traces the movement's occidental origins from 'natural philosophy' in pre-Renaissance Europe, through the Modernist era of strict disciplinary divisions, to the present-day dissolution of boundaries.

Advancing frameworks of co-creation, this paper culminates in a reinforcement of the importance of pluralistic perspectives in research through the participation of diverse publics. It concludes by stressing the importance of fostering environments where a range of perspectives and research methodologies can mingle and thrive, acknowledging the potential of these efforts in addressing the complex global challenges presented by climate change.

Keywords

Interdisciplinarity, SciArt, Co-creation, Research-Creation, Historical Perspectives, Intellectual Polarization, Natural Philosophy, Open Science, Citizen Science

Introduction

Recent years have seen a resurgence in the practice of research-creation at the intersection of science and art, propelled primarily by advancements in computational modeling, sensing, and the growing urgency of climate change. Technological evolution has led to the widespread availability of sophisticated and affordable tools, facilitating the democratization of tool access. Today, artists and members of the public alike can utilize equipment comparable to that found in university laboratories. These advancements laid the groundwork for a proliferation of conversations around open science and led to a proliferation of citizen science initiatives and art-as-science experimentation.

Our planet is changing at an unprecedented pace and facing uncertain futures. The pressing issues presented by our increasingly volatile climate act as catalysts, driving artists to employ scientific methods and tools to accurately reflect these planetary changes in their practices. This trend reflects an increasing inclination towards artworks that are not merely representational but are substantiated by real-world, and often real-time data to underscore the existential threat climate change represents. This essay aims to explore the origins of these developments and the overarching evolution of interdisciplinary research bridging art and science.

Natural Philosophy

Delineations between artistic inquiry and scientific experimentation were not always as clearly defined as they are today. In pre-Renaissance Europe, before the establishment of modern science, its precursor was "natural philosophy." This was the pursuit of knowledge about the physical universe. This practice was not just a precursor to the scientific method but a holistic approach to knowledge creation, as championed by Aristotle (384–322 BCE). His methods centered around cycles of induction and deduction. Aristotle inducted “general principles” about the world from observation, deduced theories from these principles which were checked against further observation, and so forth. These practices included drawing from observation and literary forms of writing in conjunction with mathematical measurement and calculations.

Researchers who engaged in natural philosophy, predominantly members of the aristocracy, maintained this broad and varied approach until the paradigm shift initiated by Sir Francis Bacon (1561–1626). Bacon critiqued Aristotelian methodology for its potential to yield erroneous conclusions. According to Bacon, a more stringent approach was needed. An empiricist, he believed in the primacy of empirical evidence gathered through direct observation as the foundation for scientific knowledge, thereby promoting an objective methodology that minimizes personal biases and preconceptions. His approach can be understood as the systematization of rigorous experimentation to test and disprove theories and further, the divorcing of the observer from observation. The applied impact of his work laid the foundation for what would become the modern scientific method, marking a pivotal departure from the more integrative methods espoused by natural philosophy.

Even so, echoes of natural philosophy's integrative approach did not disappear altogether, and certainly not overnight. It continued to be reflected in the perspectives of scholars such as Alexander von Humboldt (1769–1859). Humboldt's explorations in South America are a notable testament to the ongoing blending of scientific precision and artistic expression.

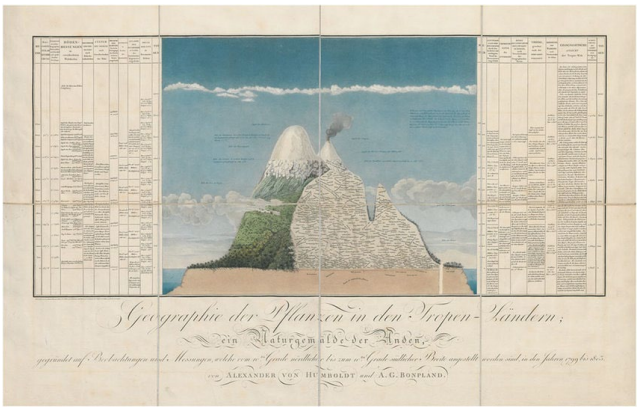

Figure 1. Alexander von Humboldt and Bonpland, 'Naturgemälde der Anden', 2' x 3'. Considered by some to be ecology's first infographic, this poster charts the distribution of plant species by elevation in addition to data on altitude, climate, and the heights to which previous mountaineers had ascended. ©Peter H. Raven Library/Missouri Botanical Garden (CC BY-NC-SA 4.0), Biodiversity Heritage Library

Humboldt's notebooks are replete with meticulous measurements and vivid descriptions, balancing detailed scientific records with rich, personal narratives of the landscapes, flora, and fauna he encountered. For example, his iconic description of Andes Mountain Chimborazo, which is considered by some to be the first ecological data visualization.[1] Humboldt's work exemplified his conviction that a complete understanding of nature required not only objective data but also the acknowledgement of subjective personal experiences. His careful documentation of his emotional responses during his expeditions further underscored this belief.[2]

Intellectual Polarization

Humboldt, while practicing both, acknowledged the increasing separation of art and science into distinct disciplines. This bifurcation of intellectual paths, unusual in Humboldt's time, became more pronounced and typical in subsequent centuries. By the twentieth century, the divergence between artistic and scientific methodologies was profoundly evident.

C.P. Snow, a scholar of humanities due to his early scientific training, vividly described this schism in his seminal 1959 essay, 'Two Cultures and the Scientific Revolution.' Snow articulated his firsthand observations of an academic world split into two divergent camps – the humanities (art, literature, history, and philosophy) and STEM (science, technology, engineering, and mathematics) – each operating in isolation and with a growing mutual incomprehension. He observed that despite similarities in intelligence, social origin, and income, practitioners within the two groups were diverging to the point of almost complete non-communication.[3]

Snow's essay also highlighted a critical issue in the world of academia: the entrenched elitism in research practices and the necessity for democratizing knowledge. This divide, prevalent not only in England but across North America and other occidental nations, emphasized a rigid compartmentalization of disciplines, an approach that Snow argued was detrimental to intellectual progress and societal advancement. His poignant critique served as a precursor to an essential and fortunately, growing, discourse on the need for more inclusive and collaborative research practices.

The Invention of Interdisciplinarity

On the other hand, the twentieth century also witnessed the emergence of more visionary thinkers who, like Humboldt, refused siloed thought and sought to bridge the divide through their work. Among them was Gyorgy Kepes (1906-2001), an artist and scholar who challenged the prevailing dualistic perception of human knowledge and experience in an essay contemporaneous with Snow's, arguing passionately for the interdependence of art and science.

He posited that these were two fundamental human activities and that they could only achieve greater advancement through mutual enrichment, not isolation.[4] Kepes, initially a painter, evolved his practice to embrace new media, pioneering kinetic and light artworks at MIT where he founded the Center for Advanced Visual Studies in 1945. This center marked a significant shift in the academic landscape, integrating the arts into the research laboratory and establishing a novel paradigm for creative practice. Collaborating with engineers and scientists across the university, Kepes championed interdisciplinary work, which he termed "interthinking" and "interseeing."[5]

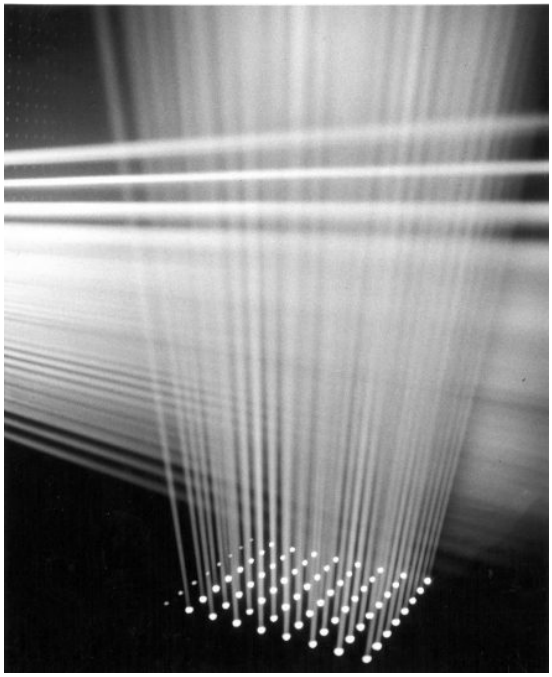

Figure 2. Gyorgy Kepes, simulated light architecture for Boston Harbor, 1966. Photo: Nishan Bichajian, 1966. Center for Advanced

Visual Studies Special Collection, MIT Program in Art, Culture and Technology, Massachusetts Institute of Technology. ©MIT.

His approach, however, was not without its challenges. Within the institutional framework of MIT, which was steeped in the very disciplinary divisions he sought to overcome, Kepes faced controversy. As a result, some of his most ambitious projects remained unrealized. For example, a civic monument comprised of "data fountains" or "information beacons" which were to be "high luminous columns that report on fluctuating levels of water, air, noise and pollution."[6] Not aesthetic only, this was to be functional as well, providing water purification as a public service. In his words:

> an immense, transparent, kinetic structure that would make the hydraulic processes visible: a contained, but legible ballet of water forcing through obstacles of filters, tinted and purified by chemicals, or moving sluggishly in intricate but legible patterns of transparent containers.[7]

Highly complex, the project would have required the collaboration of not only artists and scientists but also sociologists, telecommunications engineers, and multimedia experts. Although the work was never produced, it is easy to see how it prefigured more contemporary public works such as the data visualization Particle Falls by Andrea Polli. Despite the hurdles, many of Kepes' projects came to fruition and his efforts at MIT proved foundational in pioneering methods for interdisciplinary research in American universities.

Scientific Artistry

The legacy of Gyorgy Kepes and his interdisciplinary approach has evolved into the present day through initiatives like MIT's Center for the Arts, Science and Technology (CAST). CAST has significantly expanded the collaborative landscape, placing over ninety artists in labs across the institute.[8] Their objective transcends mere collaboration; it aims to create equal partnerships where the resulting work is as innovative and insightful for the scientists and engineers as it is for the artists. This approach, more widely accepted now than in Kepes' time, has paved the way for projects where artists function simultaneously as scientists, co-producing outputs that are both artistic and scientific advancements.

A notable collaboration at CAST involves the joint efforts of Tomás Saraceno and Markus Buehler. Saraceno, drawing creative inspiration from spiderweb building techniques, has crafted intricate gallery installations using cable and wire to mimic these natural structures. Buehler, a materials scientist with a keen interest in music, saw the potential for a unique collaboration. Together, they explored the possibility of deriving music from the webs, pondering over the idea that multispecies engagements with these structures could offer a new source of musical inspiration, vastly different from conventional human experiences.[9]

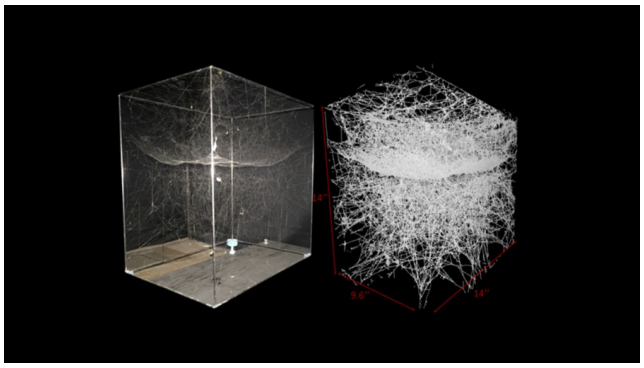

Figure 3. Real and 3D modeled spider web, Tomás Saraceno and Markus Buehler with work from postdoc Zhao Qin and graduate student Bogda Demian, 2014. ©Tomás Saraceno.

Their joint endeavor, recording spiderwebs during construction, not only produced novel musical compositions but also advanced our understanding of spider communication. Through the development of a digital twin, accurate analysis of web architecture was possible for the first time. The results of their explorations have been manifested in new artworks, performances, and peer-reviewed publications. The project's success is such that it continues to yield ongoing discoveries, including potential applications in 3D printing technology based on spider web scaffolding techniques.

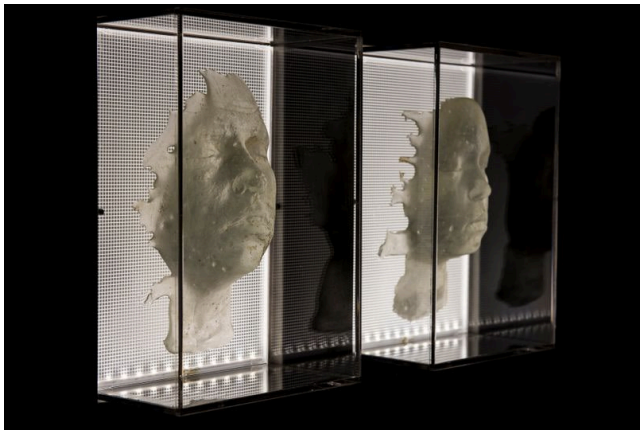

Figure 4. "Heirloom" by Gina Czarnecki and John Hunt, 2016. ©Gina Czarnecki

Another groundbreaking SciArt collaboration is the project "Heirloom" from 2016, created by British artist Gina Czarnecki in collaboration with clinical scientist John Hunt from the University of Liverpool's Institute of Aging and Chronic Disease. Together, they developed innovative methods for growing tissue in sculptural forms from cultured cells. The cells were sourced from Czarnecki's daughters and grown in the shape of their faces, creating living portraits. This artistic process led to the invention of new clinical techniques for culturing stem cells in compound curves, addressing a significant challenge in applications where cells had previously been grown flat and then stretched over curved surfaces.[10] The breakthrough has

revolutionized the tools available for treating burn patients. The artwork "Heirloom" has since been exhibited globally in major galleries and museums, such as FACT (Foundation for Art and Creative Technology). This project, like Buehler and Saraceno's, demonstrates how cross-disciplinary collaboration can unlock solutions in multiple fields simultaneously.

Unexpected Outcomes

The collaborative endeavors exemplified by the works supported by CAST, are distinguished not only by their innovative nature but also by their open-ended research approach. This philosophy aligns with the belief that the most impactful and meaningful research is often driven by curiosity rather than a predetermined goal. For example, projects at CAST are open by design, "organized more around the free pursuit of ideas than any predefined product, and, as a result, particularly in the case of Saraceno, they often lead to wild and unexpected outcomes."[11] Such an approach, embracing the element of serendipity and the freedom of exploration, has historically underpinned many significant scientific discoveries and artistic projects. For example, the fundamental Maxwell Hertz theory, that light is an electromagnetic wave, which underpins many important subsequent inventions owes its very existence to this curiosity-driven approach.[12]

While goal-oriented research within specific disciplines is undoubtedly valuable, there is a compelling argument for maintaining space within the scientific community for alternative methodologies and creative approaches, even in the so-called hard sciences. The integration of the arts into the research process enriches this exploratory landscape. Artists, like scientists, are astute observers of the world around them. Furthermore, they possess a unique abilities to communicate their observations and insights in ways that can inspire and resonate with broader public audiences. This blend of scientific inquiry and artistic expression creates a fertile ground for innovation and fosters a deeper engagement with the research process, ultimately enriching the societal impact of scientific endeavors.

A recent example can be seen in the work of Brandon Ballengée, a unique individual who is both an artist and a biologist by training. Throughout his life, Ballengée's exploratory walks through various ecosystems have positioned him to observe environmental changes caused by human activities. When nitrogen and phosphorus pollution from agriculture, ranching, and residential runoff led to a significant rise in amphibian deformities and fatalities in the mid nineteen nineties, Ballengée was among the first to notice.[13]

As an environmental activist and artist, Ballengée responded by focusing his efforts on documenting this concerning phenomenon. He developed a special chemical process that renders skin and other tissues transparent while staining bones and cartilage in vibrant colors. This was not only immediately helpful in enabling Ballengée to create striking photographic records of the affected frogs but has also been proven to be a widely adopted technique for scientific imaging.[14] His series of lightbox reliquaries, titled Malamp, features these images, which are both aesthetically captivating and emotionally evocative (Figure 5). Ballengée views the dissemination of scientifically accurate, visually provocative information as a critical component of engaging the public in environmental research and activism. In an interview with the Smithsonian, he elaborated on his philosophy:

> I'm really interested in the term activist meaning "to activate." Imagine if you can activate people to look at an environment as all those little individuals – all those little insects, all the little frogs, all the organisms that are out there – as part of their community. Getting people to look at ecosystems that way, I think, really changes their perspective and their actions and behavior. I just love the idea of sculpting society through ideas. That way you can activate and inspire one another toward better and more sustainable behaviors.[15]

Figure 5. Brandon Ballengée, DFB 45: Arès. 2008. Unique digital-C print on watercolor paper. Cleared and stained Pacific tree frog collected in Aptos, California in scientific collaboration with Stanley K. Sessions. Title by the poet KuyDelair. 46 x 34 in.©Brandon Ballengée

Ballengée's approach extends beyond the creation of art to the facilitation of citizen science. He invites interested members of the public into the field with him during his studies of amphibians on outings he calls "ecoactions," which serve as a form of citizen science or participatory biology. These excursions are about mutual learning: "I'm learning from them too… I'm often a tourist as a researcher…going in for a year or two and don't have the background of growing up in the area."[16] This approach

embodies the spirit of open science and collaborative culture.

Pluralistic Perspectives

The practice of interdisciplinary research, especially when it opens doors to public participation, offers substantial benefits to society. The principle of pluralism in science posits that multiple theoretical perspectives within the same domain can each yield valuable insights:

> alternative theoretical perspectives within the same domain or scope of inquiry may each yield useful insights, depending on the questions of interest and the goals and values in play... assuming that scientist diversity is correlated with diversity in methods and theoretical orientations, we have a compelling reason to believe that scientist diversity makes for better science.[17]

This concept aligns with the observations of researchers like Bethany Ojalehto and Douglas Medin. In their study "Seeing Cooperation or Competition: Ecological Interactions in Cultural Perspectives," they found that cultural models in observers' minds influenced their perception of interspecies relationships. When shown the same images of hunting interactions between wolves and badgers, a majority of Indigenous Panamanian Ngöbe participants interpreted the interactions as cooperative, while most non-indigenous U.S. participants viewed them as competitive.[18] Interestingly, this study also echoes the sentiments of many early natural philosophers including Alexander von Humboldt, who firmly believed in the inevitability of subjectivity and, thus, the necessity of including personal opinions and emotional reactions in scientific research.

If absolute objectivity is not possible, it stands to reason that holistic perspectives in science can only be achieved through increased diversity in its practitioners.[19] Furthermore, collective action in research and citizen science initiatives can help facilitate a multiplicity of perspectives, thereby reducing biases and cultural hegemony in research. Divergent disciplines and methods provide a means to grasp complexity, as do the varied perspectives arising from different life experiences. The collective approach offers a pathway to inclusivity:

> Collectivity is multiperspectival by nature and, when designed intentionally, offers a way to be inclusive. Divergent disciplines and methods provide a way to grasp complexity, but so too do the perspectives that emerge from different life experiences.[20]

Artists often lead the way in diversifying research practice, even in the face of limited resources. A prime example can be found in the work of Camila Marambio, who since 2010 has spearheaded Ensayos, a collective research initiative that "brings together artists, scientists, and activists to conceptualize long-term, process-based projects focused on ecocultural conservation."[21] Ensayos, centered in Chile, specifically in Tierra del Fuego, demonstrates the power of multiperspectival activities in influencing both local and global perspectives.

After a decade of community work carried out by volunteers on a shoestring budget, their collective efforts gained momentum. In 2022, Ensayos' efforts were showcased on the international stage at the Venice Biennale through the presentation of their multifaceted project, Turba Tol Hol-Hol Tol.[22] This project, which in the Selk'nam language means "Heart of Peatlands," pays homage to the Selk'nam people, who coexisted for thousands of years with the peat bogs of Karokynka/Tierra del Fuego before decimation via colonial genocide.[23] Furthermore, they were written about as extinct people in western histories of the world, despite their tenacious survival. Today the Selk'nam people are fighting to be recognized as a living culture and protect both their peatland home and their society of mutual care. Marambio, in her curatorial role, fostered Turba Tol Hol-Hol Tol to acknowledge the indissoluble connection between the peatlands and the Selk'nam, championing their voices and ways of coexisting with the environment through artistic actions and scientific research.[24]

Figure 6. Turba Tol Hol-Hol Tol, Chilean Pavilion, 2022 Venice Biennale, Venice, Italy. ©Turba Tol Hol-Hol Tol

Turba Tol Hol-Hol Tol was presented in the Chilean Pavilion of the Biennale through an immersive video installation, inviting visitors to traverse a peatmoss garden into a circular projection room constructed from bioplastic film grown from the peatland microbiome of Karokynka. The installation featured a 360-degree screen, tensioned by a steel frame, displaying video footage of the peat bogs and Selk'nam stories conveyed through song. This immersive experience was just one facet of the overarching Turba Tol Hol-Hol Tol project, which also included the SphagnumLAB. SphagnumLAB, a functional scientific experiment within the project, was built upon research from the Greifsald Mire Centre (GMC), a leading institution in peatland research.[25] The lab involved harvesting living Sphagnum moss from Karokynka and creating a conducive environment for its growth within the pavilion, with data on its growth being recorded throughout the exhibition's

duration. Peatland is a biome more efficient at trapping carbon than any other, and yet someone one of the least studied.

'Turba Tol Hol-Hol Tol' stands as a rare and exemplary model of collective wisdom in action. It was co-created by a diverse team of hundreds, combining the expertise of curators, art historians, architects, filmmakers, poets, scientists, and indigenous knowledge bearers. The project's success was further bolstered by the support and recognition from the Chilean Ministry of Cultures, Arts and Heritage, and the Ministry of Foreign Affairs.[26] This collaborative effort, both hyperlocal in its focus and global in its impact, has garnered support for preserving local ways of life and attracted international attention.

Conclusion

The resurgence of research-creation at the intersection of science and art, as exemplified by the works of Tomás Saraceno, Gina Czarnecki, Brandon Ballengée, and Camila Marambio among so many others, marks a significant shift in our approach to knowledge and innovation. Their collaborative efforts bridge disciplinary gaps and demonstrate the transformative power of integrating diverse perspectives and methodologies. The blending of artistic inquiry with scientific experimentation, illustrated in their projects, reveal the potential for novel insights and solutions to emerge from such cross-disciplinary collaborations.

This trend towards interdisciplinary research is not a return to the pre-disciplinary approaches of early researchers. Instead, it represents a step forward, toward post-disciplinary inclusive and comprehensive understandings of our world. The interdevelopments of art and science encourage us to view our planet and its challenges through a multifaceted lens, combining the empirical rigor of science with the empathetic and interpretive insights of the arts. In the face of pressing global issues like climate change, such collaborative efforts have become increasingly vital.

Ultimately, these intersections of art and science are testaments to the creativity and curiosity that epitomize the best of human endeavors. As we move forward, it is essential to continue fostering environments where diverse perspectives and collaborations can thrive. These spaces are critical for the kind of thinking necessary to address some of the most complex and pressing challenges of our time.

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