

INTEGRATING THE ARTS WITH STEM TO PROMOTE LEARNING AND THINKING

FINAL REPORT

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INTRODUCTION

Our group of artist-scientist scholars and practitioners were tasked with articulating the ways that arts practices impact ISL (Informal Science Learning) organizations, programs, and outcomes. In this work, we aimed to take an *arts-forward* perspective, seeing arts practices as crucial to the success of organizations and programs. The arts are not just “nice to have” in the context of ISL but rather crucial to achieving transformational outcomes for young people. Rather than frame the arts as “instrumental,” meaning as a pathway to achieving STEM-based outcomes, we focused on understanding the arts as both integrated with and inextricable from ISL. With this framing in mind, we addressed the following question: **How do the arts equitably engage and teach diverse youth in STEM?**

How we approached the inquiry

This inquiry was conducted in two steps. First, our cohort participated in two focus groups where we discussed internally how to think about the role of the arts in ISL, particularly as arts practices can positively transform the lives of young people who have historically been marginalized from mainstream institutions¹. These conversations revolved around four substantive questions and two process questions:

- Why does it matter that we center the arts in work focused on STEAM and equity?

¹ Transcripts for these focus groups are available, if they can be of use in the future.

- How do we define arts integration specifically as it applies to integration with STEM?
- How do we define equity in the context of STEAM/arts integration experiences?
- What tensions emerge as we try to construct these definitions?
- What kind of literature base is required to answer these questions?
- Who is this work for and how does that shape what we make?

We then brought these questions and our initial thoughts about how to answer them to the whole group during our NSF grant July in-person meeting. During this meeting, our inquiry became consolidated. First, we had extensive discussions about the audience for our collective work. This discussion resulted in an understanding that we aim to speak to researchers, practitioners, and policy makers in the field of ISL. Therefore, our writing should be research-based, accessible, and action-oriented. And while we could “go deep” on the theoretical foundations for learning in and through STEAM, the purpose of this paper is to offer digestible, practice-based ways forward. These discussions resolved our process questions.

Second, the entire group sought to define equity with respect to ISL organizations and programs. This conversation resulted in the definition(s) found in the document titled, “STEAM for All”. We provide a summary of our arts-specific equity findings, but they should be read as a complement to the more comprehensive document.

Finally, when our cohort presented to the whole group, we spent a good deal of time discussing the tensions that emerged when trying to center the arts in ISL research and practice. It became clear that these tensions were not resolvable through conversation but rather are opportunities for future research, should we wish to continue to focus on the role of arts practices in ISL especially in addressing issues of equity.

KEY FINDINGS

Why does it matter that we center the arts in work focused on STEAM and equity?

We identify four big ideas for why the arts matter in our work with ISL and equity:

- 1) Research on learning in and through the arts describes development of the following skills and habits of mind: Creativity, imagination, innovation, risk-taking, conflict resolution, peace building, collaboration, agency, comfort with communication, reflective practice, adjacent possibilities, and perspective-taking. All of these potential outcomes have been identified as important in ISL and engaging in arts practices is a demonstrable way to promote these skills and habits of mind with learners. Notably, many of the studies documenting

transformative outcomes focus on young people who are from historically marginalized backgrounds - students of color, students with disabilities, LGBTQ+ students, and young women.

- 2) Specifically, the arts allow us to embrace a “tinkering mindset”, a different way of thinking in environments that are “doing science”, specifically through design, problem solving, and an emphasis on creativity. This version of the arts has emerged from the Maker Movement, a branch of arts-integrated STEM practice that has opened new possibilities for ISL.
- 3) The arts can also serve an instrumental purpose in engaging young people with ISL and STEM. Arts-based curricula may improve STEM learning outcomes for all students, especially for those who have been turned off from school-based math, science, and engineering. This is in large part because the arts offer common spaces for engaging with STEM through valuing divergent approaches and outcomes from across communities, notably underrepresented and historically marginalized communities.
- 4) Perhaps most importantly, the arts bring humanism and subjectivity to inquiry. Art-making is a fundamental part of human development and to devalue the arts in our learning environments is to devalue what it means to become human.

How do we define arts integration specifically as it applies to integration with STEM?

One of the biggest challenges of our work is that we lack a singular definition for “arts integration”. Through a review of the literature and our conversations as a cohort and a full group, we propose five ways to understand arts integration in ISL:

- 1) *As processes, routines, and structures for learning.* These processes have inherent qualities and capacities that are broadly applicable across learning environments. Examples include: tinkering, critique, and metarepresentational competence.
- 2) *As an integrated discipline.* This version of arts integration looks like transdisciplinarity, where we are no longer concerned with whether a project or an outcome is in “science” or “math” or “visual art” but focus instead on what people make and do and the kinds of explanations they give for their work.
- 3) *As a shared epistemological understanding of what it is to “do” science and “do” arts.* Similar to transdisciplinarity, but really focused on shared commitments to making knowledge. The art-science movement focuses on epistemological

overlap and many Indigenous education researchers have developed art-science programs and practices where art and science outcomes are one and the same.

- 4) *As STEAM.* This is the most common understanding of arts integration; that “art” is an add-on discipline to science, technology, engineering, and math (STEM) disciplines. While this is appealing from a policy perspective - just add “art” to your list of offerings - it is also the easiest to do poorly. We noted multiple examples of the art project phenomenon, where programs added an art component to their science or technology project and called it STEAM.
- 5) *As a perspective shift to see problems differently.* Practitioners described the role of the arts in their programs as a reframing of how learners approached their work. Making art is often a less intimidating way into a problem-solving process, so there is a positive psychological impact, especially for learners from minoritized groups. And making art allows us to approach problems in new ways. Research on embodied cognition, for example, has shown that movement and (literal) hands-on projects change the way that learners understand tools, materials, and processes. We see this with all forms of dance as well as visual art forms including glass blowing, weaving, and ceramics.

How do we define equity in the context of STEAM/arts integration experiences?

Here we provide a few notes from our discussion of the definition of equity within STEAM and arts integration experiences that complement the more comprehensive document:

- Equity is about both *access* and *representation* in art-making experiences and a *sense of belonging* with or across communities of practice.
- Equity means supporting populations who have historically been marginalized from public institutions - this includes a range of identities including “diverse youth” (BIPOC, youth of color, Indigenous youth), English Language Learners, young people with disabilities, queer youth. Understanding who and how to support marginalized populations requires an international perspective.
- Equity means *inclusion* and asking, “who is absent from this conversation?”
- The arts have a few key features that can explicitly address issues of equity:
 - Young people *develop agency* through participation in the arts, particularly young people who have a history of feeling non-agentic in schools and other organizations.

- The arts allow people to *embrace discomfort*, a key feature of being open to working alongside those who are different from you.
 - The arts allow us to center a diverse set of cultural and knowledge assets, notably from people who have experienced marginalization. Examples include traditional ecological and Indigenous knowledge, lived experiences of immigration or displacement, and a range of forms of storytelling.
 - Artmaking is a fundamentally relational practice.
- Access to high quality arts experiences IS an act of equity; currently the arts are often considered to be for those who can afford the time and money.
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PRIORITIES FOR FUTURE WORK

We see the tensions that emerged from our conversations about the role of the arts in promoting equity across ISL as opportunities for future research and practice. We offer four such directions:

1. There are multiple ways the arts can fit into the landscape of ISL and equity practice – we can integrate the arts, we can engage in arts integration, or we can work across disciplinary boundaries and be more inclusive of values, knowledge, and expertise from non-academic sources. What is the most impactful for young people?
2. How do we make the conversation between artists and scientists bidirectional? In research and in practice, artists see the value of collaboration and integration, but scientists often need to be convinced. STEM is still seen as the “more valuable” part of the collaboration.
3. How do we avoid the “art project” version of integration (i.e. take your science project and decorate it)? We often see that when STEM practitioners aim to engage the arts, they see the arts as an “add on”, a method of engaging learners but not deeply integrated into the learning processes and outcomes of their work.
4. Given that many ISL educators do not see themselves as artists, how do we engage in professional learning so that educators feel knowledgeable and empowered to design meaningfully with the arts?

The case studies we have presented begin to answer some of these questions. The training of artist-mentors, for example, is present across all three projects and involves expanding who is considered an educator and how they can work effectively with young people. The use of mentors in ISL spaces is a promising practice for empowering educators to integrate arts practices into their work. The cases also demonstrate how artmaking engages young peoples' personal, cultural, and historical resources as they learn. An asset-focused approach to learning is both one of the benefits of centering the arts and a strategy for promoting equity in ISL environments.

CASE STUDIES

Case Study 1: Digital Youth Network

"Designing for equity. Changing what's possible. Together." From their website:

Digital Youth Network (DYN) is a research lab focused on designing more equitable systems for youth. We are a team of researchers, product designers, technologists, and practitioners that have worked at every level of the out-of-school time space since 2005.

We have led citywide OST networks, redesigned how public libraries can engage youth, delivered STEAM programming for thousands and developed a purpose-built infrastructure specifically for OST. (digitalyouthnetwork.org)

DYN is a systems approach to equity in education through STEAM programming for young people across Chicago (Barron et al., 2014). At the systems level, they engage in *opportunity landscaping*, a method of identifying what STEAM opportunities are available for young people across Chicago and where opportunity deserts exist. These opportunity deserts become places of possibility for the design of new programs. DYN has also built *learning platforms* that provide a digital footprint for young people that they can access across their learning ecology. Students can access work, start new projects, and create a portfolio that stays with them across the different learning spaces they occupy. This is especially important for positive identity work as young people come to see themselves as makers and doers of STEAM through their persistent online identity. DYN also partners with OST organizations to train mentors to facilitate STEAM programming. These "grow your own" mentorship programs strengthen communities and provide opportunities for young people to grow into instructional roles.

DYN is primarily a resource for local organizations to design and host their own STEAM programs in their local communities. Their resources include STEAMville, an online platform with a range of projects and challenges across disciplines as well as online communities to support engaging in the projects. DYN also hosts STEAMBassadors, a program to train college students from two and four-year institutions to work with middle and high school youth on STEAM projects. STEAMBassadors support local organizations and schools across Chicago to engage minoritized young people in STEAM learning.

The Digital Youth Divas program is a DYN-run STEAM program for middle school girls from historically marginalized communities. This program aims to engage girls of color in STEAM learning with an eye towards developing positive STEAM identities and interest in future learning and STEM careers. The activities merge design, computer science, and the arts through storytelling (Pinkard et al., 2017), dance, and the creation of artifacts (Pinkard et al., 2019) that engage the assets and interests middle school girls bring to their work.

Case Study 2: Cool Science

“Art + Science = Learning for All.” From their website:

The Cool Science team brings a new approach to the challenge of improving public understanding of climate science.

Cool Science aims to engage students, teachers, parents, and the general public from Massachusetts, Kansas, and Missouri with the science of extreme weather through a statewide K-12 student art competition designed to foster learning about climate science. Students (and their teachers) are encouraged to develop a visual work of art that addresses one of three questions about extreme weather. Winning entries have their work put on public display on local regional bus transit authorities (coolscience.net).

Cool Science focuses on the phenomenon of extreme weather through the intersection of science and art. The project provides students with resources and background on the science of weather, focusing on “extreme weather events”. Students then produce art representing extreme weather to demonstrate their understanding of these phenomena. There are a series of art contests where the winners’ work is displayed on public buses in order to engage the public in conversations about extreme weather. Research has demonstrated that young artists learned about climate science through making art and that these artworks are effective communicative tools for public understanding about climate change (Lohmeier et al., 2021). While the project began in Boston it has now

been replicated in Kansas and Missouri, resulting in a program model that may extend beyond the original organization.



Congrats to Kaylin, a 10th grader from Tyngsborough, the Massachusetts David Lustick Winner!



Congrats to Dhairya, a fifth grader from Kansas City, the Kansas David Lustick Winner!

Case Study 3: Hand and Machine

Hand and Machine is a research lab in the Department of Computer Sciences at the University of New Mexico. From their website:

We explore relationships between technology, materials, and culture. We invent new technologies that are inspired by the rich cultural and material diversity of the physical world. We believe that by making technology more accessible and using computers in novel, unexpected contexts, we can change and broaden the culture of technology. We aim to create new artifacts and tools that have an impact both within and outside of academia—shifting and expanding the technical and cultural landscape of technology (handandmachine.org).

Their work takes a transdisciplinary approach to STEAM and making, focusing on producing artifacts at the intersection of technology, computer science, biological science, and the arts. Examples include the development of a new ecologically and socially situated eggshell biomaterial for 3D printing, algebraic surface sculptures, 3D printed biomaterials objects that explore multispecies relationships. Of particular interest for us is PAHTIA, an interactive site-specific mural that creates shifting soundscapes in response to touch. PAHTIA was co-designed in collaboration with middle and high school students who worked on all aspects of the project. The result is both technologically sophisticated and culturally responsive, focusing on ancient healing practices through sound that required using Aztec, Mayan, and Anasazi designs.



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