I/CaLL: Community Science Learning

Project: **Indianapolis: City as Living Laboratory**

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Executive Summary

I/CaLL is a four-year project that explores art as conduits for informal science learning on a citywide scale. The project attempts to transform the city of Indianapolis into an informal science-learning museum through the use of sculpture, dance, music, and poetry as educational tools in creating awareness and understanding of the city's waterways. Specifically, I/CaLL addresses five sites located near and around waterways in impoverished or underserved communities, where art interventions created by artists in collaboration with scientists address topics around water sustainability. Additionally, these interventions are intended to address community needs in order to augment the connections people feel with their environments.

This report looks at a series of discussions I/CaLL team members hosted at local libraries in Indianapolis in which the intersections of art and science were explored, and a range of I/CaLL programming events created to engage the public community of Indianapolis with topics and issues addressed by the project's efforts. Our findings reveal the importance of engaging the public in the discourse of how art and science can work together to raise awareness. Discussions and events helped forge bridges between these disciplines in the public eye and begin to lay the foundation for creating more pervasive collective shifts in science reasoning through the arts. Specific to this project, these discussions appear to nurture a community in which art and science interventions – such as sculpture, music, dance, and poetry – may begin to plant the seeds of behavior change.

Introduction

In 2013, the Center for Urban Ecology at Butler University was awarded a National Science Foundation grant (#DRL-1323117) to explore informal science learning opportunities on public lands in Indianapolis, Indiana. The five-year project, entitled *Indianapolis City as a Living Laboratory: Science Learning for Resilient Cities* (I/CaLL), investigates how different types of art can be used as conduits for informal science learning on a citywide scale. The project set out to explore art and art process as a new strategy for enhancing informal science education about environmental sustainability. As a collaborative endeavor, the project brought together earth science researchers, artists committed to exploring environmental issues, and social scientists who sought to explore cultural phenomena related to professional collaborations and public encounters with the art products.

Butler University collaborated with Indiana University - Purdue University Indianapolis (IUPUI), Mary Miss/City as Living Laboratory, Reconnecting to Our Waterways (ROW), and New Knowledge Organization Ltd. (NewKnowledge), in addition to individual artists and curators on the project.

The I/CaLL project has been publicly referred to as StreamLines within the Indianapolis community. In this report, the two names are used interchangeably.

I/CaLL leadership selected five sites adjacent to waterways in a range of Indianapolis communities where artists were invited to create installations, performances, or art works based on these sites to support an experiment in advancing public informal earth science literacies in the greater Indianapolis region. The five waterways were considered particularly useful for this experiment because they are found within a twenty-minute walk for most residents in the central Indianapolis area. Ultimately, the project's outputs aimed to increase the connections between people and their environment.

I/CaLL social science researchers are studying how artistic installations and programs at Indianapolis waterways can promote community engagement and science learning among city residents. The key questions guiding this research are: 1) How do art experiences prompt science reasoning?; 2) How can we measure and define scientific literacy, growth, and vectors for science learning in a community?; and 3) How does informal science learning happen as part of family and civic life outside the home?

This study of approaches to and perspectives on art-science collaboration focuses on the first and second research questions. Specifically, for the second research question, we focus on how art-science collaborations can serve as a vector for increasing science literacy, as a way to understand how to define and measure the public's science literacy and growth.

SCIENCE LITERACY

Science literacy, as a term, was introduced in the late 1950s (DeBoer, 2000, Yore, 2012). It has had many definitions since then. Looking at the history of this term and how it has been used, DeBoer (2000) notes that science literacy implies a "broad and functional understanding of science for general purposes... It defines what the public should know about science in order to live more effectively with respect to the natural world" (p. 594). DeBoer felt it was unadvisable to measure science literacy quantitatively, explaining that there is no quantifiable body of knowledge that represents science. Instead, he advocated to nurture a public's interest in science and offer them the tools needed to apply it to their own lives. He remarked, "The goal of science literacy is achieved when the public learns about science and about the scientific enterprise in the many different ways that this can be accomplished" (DeBoer, 2000, p. 597).

Refining this definition of science literacy, for the purposes of our research, we acknowledge a hierarchical approach to science literacy as suggested by the literature. We use a multidimensional definition of science literacy, adapted largely from Shamos (1995), where:

- **Cultural science literacy** implies an individual has the factual information needed to read newspapers or

magazines about science topics. This dimension of literacy is characterized by memorization rather than a dynamic understanding of scientific terms;
- **Functional science literacy** signifies a deeper understanding of science ideas from which adults can engage in meaningful conversation about scientific issues; and
- **True science literacy** indicates knowing the theories of science and being aware of major concepts and systems that form the foundation of science. This dimension implies an understanding of the role of experimentation in science, the importance of objective evidence, and the scientific method.

THIS STUDY & REPORT

This report specifically focuses on the first and second of our three main research questions: "How do art experiences prompt science learning?" and "How do we measure and define science literacy growth in a community?"

In order to address these questions, we include an analysis of a series of discussions called Art + Science Brainstorms that address intersections between art and science, and findings from surveys and interviews conducted at StreamLines programming events throughout the year of 2016.

Art + Science Brainstorms

Art + Science Brainstorms address the intersections between art and science through public discussions held in Indianapolis Public Libraries around the city. These dialogues were created as a way to foster awareness about the intersections between art and science and inspire informal science literacy at a community level. By engaging the public to hear about their experiences with art and science reasoning, the Art + Science Brainstorms offer the foundations of how our first two questions can be answered.

StreamLines Programming Events

A series of StreamLines events occurred over the course of the project. These events were organized between I/CaLL team members, the artists, and participating organizations. Event intercept surveys were collected at the following events:

- Children's Museum Family Night
- Catherine Bowman Poetry Reading / Pogue's Run
- Butler Art's Fest Big Test Installation
- White River Stream Walk
- Catherine Bowman Poetry Reading / Fall Creek
- Alessandra Lynch Poetry Reading at the Canal

Art + Science Brainstorms

INTRODUCTION

Public engagement for I/CaLL has taken place in a number of ways (see NewKnowledge Report #NSF.097.115.10 StoryBook). This report discusses Art + Science Brainstorms, which are a series of discussions taking place in Indianapolis Public Libraries (IPL). Art + Science Brainstorms started in August of 2015 and continued through the fall of 2016, occurring roughly every quarter year. These discussions were originally created as an extension of the Art + Science Roundtables conducted by Mark Kesling, CEO and founder of The daVinci Pursuit. Unlike the Art + Science Roundtables, which are by invitation only, the Art + Science Brainstorms are open to the public and serve the purpose of extending the conversation about intersections between art and science to the general public of Indianapolis.

METHODS

To date, Art + Science Brainstorms occurred over the course of slightly more than a year. Each discussion took place in an IPL close to an I/CaLL waterway site. All library discussions sites and their associated I/CaLL waterway sites are listed in Table 1.

Each library discussion lasted roughly one hour, with significant opportunities for questions and answers from the discussion attendees. The content and themes of the discussions always covered the general topic of intersections between art and science, but were not always directly related to StreamLines.

Details of the discussions were unstructured and primarily guided by the composition of participants who joined the conversations. That is, they often addressed issues specific to nearby neighborhoods or as otherwise influenced by those attending.

Table 1. Library discussion sites.

Date	Location	Waterway
August 10, 2015	College Avenue Branch	Fall Creek
August 11, 2015	Spades Park Branch	Pogue's Run
December 14, 2015	Eagle Branch	Little Eagle Creek~
December 15, 2015	Fountain Square Branch	Pleasant Run
March 14, 2016	Haughville Branch	White River
March 15, 2016*	West Indianapolis Branch	White River
May 12, 2016	Glendale Branch	Canal
June 13, 2016	College Avenue Branch	Fall Creek
June 14, 2016	Spades Park Branch	Pogue's Run

Note. * = not included in the analysis due to lack of participation.

Note. ~ = Little Eagle Creek was originally an I/CaLL site, however by 2015 it was no longer included in the study. Remnants of inclusion are still seen as with the inclusion of library programming here.

PARTICIPANTS

Art + Science Brainstorms were open to the public and publicized by the community organizer for I/CaLL, Molly Trueblood, at the monthly neighborhood meetings she attends as part of her greater I/CaLL work. Along with Molly Trueblood, Ryan Puckett, founder of TWO21 and head of PR for I/CaLL, created a flyer that was placed on local library bulletin boards (see Appendix D for an example). Art + Science Brainstorm dates were also publicized on the StreamLines website and StreamLines social media pages.

Discussions comprised 4-13 participants from the public. In addition, different scientists and artists were included in each library discussion session as organized by Molly Trueblood.

Originally, each Art + Science Brainstorm was to be facilitated by at least one artist and one scientist, either

related to I/CaLL or from the city of Indianapolis. Due to scheduling constraints, this was not always the case. Sometimes no artist was available to attend. In these cases, a scientists or educator, and an I/CaLL team member would host the discussion. The selection process of artists and scientists was based largely on availability, and scientists and artists often attended more than one discussion. Molly Trueblood, the community organizer for I/CaLL who has maintained communications with all neighborhoods linked to the five I/CaLL sites, organized the talks and was the only one to participate in all discussions. She was also in charge of choosing artists and scientists to help facilitate the discussions. Aside from Molly Trueblood, facilitators who participated were all team members of I/CaLL and included, Travis Ryan, PI, Mark Kesling, CEO of The daVinci Pursuit, Gabriel Filippelli, Director of IUPUI Center for Urban Health, Amber Rollings, doctoral student, Cynthia Pratt, choreographer, and Stuart Hyatt, musician. See Table 2 for full list of facilitators at each site.

Table 2. List of Art + Science Brainstorm facilitators at each site.

Date	Location	Facilitator
August 10, 2015	College Avenue Branch	Molly Trueblood, Travis Ryan, Cynthia Pratt
August 11, 2015	Spades Park Branch	Molly Trueblood, Travis Ryan, Cynthia Pratt, Mark Kesling
December 14, 2015	Eagle Branch	Molly Trueblood, Mark Kesling, Amber Rollings
December 15, 2015	Fountain Square Branch	Molly Trueblood
March 14, 2016	Haughville Branch	Travis Ryan, Molly Trueblood, Mark Kesling
May 12, 2016	Glendale Branch	Molly Trueblood, Mark Kesling, Gabe Filippelli
June 13, 2016	College Avenue Branch	Molly Trueblood, Gabe Filippelli
June 14, 2016	Spades Park Branch	Stuart Hyatt, Mark Kesling, Molly Trueblood

ANALYSIS

Library discussions were not formalized or scripted. The conversations flowed organically from the central theme of art-science intersections while being attentive to the composition of participants present for the talk. Each discussion was audio-recorded for later analysis.

An initial coding scheme was created by three NewKnowledge researchers who were familiar with the project and understood the goals and content of I/CaLL. This coding scheme was then refined by two researchers working together in order to clarify and / or remove vague and inadequate codes. The final scheme included codes that focused on four main categories with multiple subcategories; Tone (sense of humor), Content (social support & framing the project, expertise, moral issues / ethics, solutions, audience personal connections, science and art) Art / Science Intersection (art / science discussions), and Community Organizer Role. Each of these overarching concepts is identified in Appendix C, in conjunction with their associated (and more specific) codes. Coding varied from two to three levels per code.

The research team used a time-sampling approach to code the library discussion data. In this approach, each member of the team listened to five-minute segments of the discussion audio recordings and then marked the coding sheet (1 = present, or 0 = not present) if a code was covered during those five minutes. In addition, significant or particularly striking discussion topics and codes were time stamped for further exploration. All of the coding took place in an Excel coding sheet.

A consensus coding strategy was used to ensure at least 80% agreement in codes found within the library discussions amongst NewKnowledge researchers. The coding dyad independently analyzed a subset of discussions (approximately 20% of the discussions; two discussions) and then compared responses to check for agreement and consistency in the coding procedures. This consensus coding method resulted in an above 83% percent agreement for all codes accept one, which was 79.2%. This code noted discussion on art and has been included in further analysis as inter-rater reliability was so close to 80%. We also note that

the mean inter-rater reliability across data sets was 94.4% (*SD* = 0.0634). With the establishment of a relatively high reliability, one researcher completed the rest of the coding.

The Art + Science Brainstorm on March 15, 2015 was excluded from our analysis as no participants attended this discussion. In total, our analysis included eight Art + Science Brainstorm audio recordings.

We also note that although at the beginning of the project, there were six sites, the Little Eagle Creek site is currently no longer a part of I/CaLL due to the relocation of a key non-project place-making partner. As a result, no sculptural elements have been installed at this site. However, as this change happened in year two, a musical piece had already been created and poems already selected. One Art + Science Brainstorm happened close to that site in Eagle Branch and was included in our analysis.

RESULTS

All themes were coded and tallied within each Art + Science Brainstorm, and across all eight. The most frequently coded themes are presented in Table 3. For the full list and frequency of coded themes see Appendix C.

Table 3. Most frequently coded Art + Science Brainstorm themes.

Theme	Frequency
Comparison of art and science as disciplines / using one's discipline to understand another	212
Discussion of art / artistic process, or analysis of an art piece (i.e., meaning and purpose, social purpose, inspiration)	115
Use of humor (i.e., sarcasm, irony)	75
Explanations or understanding of key concepts of disciplines (i.e., science / scientific process, culture, art, geography): Didactic	67
Knowledge around disciplines (i.e., social history, science, art, culture, geography): Conversational.	48
How can we help?	23
Tying the conversation back to self	22
Shift conversation focus to stay on task	21
Discussion of 6 sites / themes	17
Details of StreamLines	16

Unsurprisingly, the most frequently coded theme was Addressing the art and science intersection (*n* = 212). This was coded almost twice as much as the second most frequent code; Discussion of art / artistic process (*n* = 115), which was followed by the Use of humor (*n* = 75), Explanations or understanding of key concepts of disciplines (*n* = 67), and Knowledge around disciplines (*n* = 48). The least coded themes were Negative framing of the project (*n* = 1), and Utilitarian values (*n* = 1). Intrinsic value (*n* = 0) was not coded at all (see Appendix C).

The median number of codes for all themes was 12.5, while the average was 28. Half of the themes were coded under 12.5 times and as Table 3 shows, only five themes out of 26 were coded more than 23 times.

Although the Art +Science Brainstorms were an I/CaLL initiative, we note that Details of StreamLines was only coded 16 times. Discussion of 6 sites / themes was coded 17 times and Discussion of 21 science concepts (NewKnowledge Publication #NSF1.97.115.03) was coded 10 times (see Table 3 and Appendix C).

Art-Science Interactions

For the most part, participants agreed and understood about the many connections between art and science. They were open and curious to explore these intersections. Discussions around these intersections varied greatly, and were often weighted toward highlighting similarities between the two disciplines over differences. Some of the similarities mentioned were that:

- Artists and scientists are both creative;
- Art and science can both explore the 'invisible';
- Art and science are both iterative processes;
- Art and science can both be social;
- Art and science both often need patrons;
- Art and science both learn through experimentation;
- Arts and science both promote mindfulness and awareness;
- Artists and scientists inspire each other.

While some of the differences mentioned were that:

- Science attaches more importance to naming than art does;
- Science can give us answers, while art can tell us stories;
- Art aided by technology is sometimes criticized, while science aided by technology is often celebrated;
- Art is easy and science is hard;
- Science is generally easier to make a living from, while art is generally more difficult to make a living from.

Other times they talked about specific mediums in which art and science are inseparable such as art created on computers, by film technicians, or with technology such as Tilt Brush by Google (a 3D painting virtual reality program). In a couple of conversations, it surfaced that ***art is in everything*** and ***science is in everything***. Indeed, most participants were quick to realize the integrated nature of art and science and would offer examples such as, ***colors***, ***sounds in nature***, ***math is part of music***, ***cosmetics***, ***paint***, ***science-fiction***, and ***photography***.

Discussions also covered famous individuals such as Carl Sagan, Leonardo daVinci, and Neil deGrasse Tyson as examples of individuals who either embodied or embody both art and science within their life work.

Rarely did the discussion touch on the actual details of StreamLines and how art and science can specifically help Indianapolis residents or neighborhoods. Discussions were often abstract and general or if specific, pertaining to the participant's lives, professional careers, and experiences. These discussions did not address the ability of art to convey science information in a new or meaningful way. They covered overlap between the two fields but did not probe overarching questions such as how art experiences can prompt science reasoning or how informal science learning happens in life.

Discussion of Art

Art was discussed in many ways throughout the Art + Science Brainstorms, and the frequency of its discussion often depended on whether an artist was present or not. Discussion of science topics on their own were relatively infrequent. It appears participants and hosts were more interested in determining how art can be seen as part of the intersection more than science.

Of the eight Art + Science Brainstorms, Cynthia Pratt, a dance choreographer for I/CaLL, was present at two, and Stuart Hyatt, a musician for I/CaLL, at one. During these conversations, art concerning StreamLines was discussed; specifically, the art of the artists present. That being said, these discussions only skimmed the surface of the individual artist's work and relationship to StreamLines. In other Art + Science Brainstorms, art specific to StreamLines was not discussed.

Conversations around art often addressed the definition and history of art, and audience members' relationship or engagement with art. Sometimes these comments were vague such as ***Is pretty much everything art?*** and ***Human nature is artistic, so that is at the root of who we are***. Participants also discussed what ***real art*** is and if one can cheat by making art with technology. While other times they were more specific, noting facts such as ***evidence for art predates agricultural farming by 20,000 years*** and ***then there was a movement that was a really big moment... that's when art became ornamentation.***

Conversations also addressed participants' beliefs about the utility and value of art. Participants had many feelings about how art might be helpful and of value. These comments often revolved around art being able to create curiosity and questions for its audiences. For example, one said, ***good art is thought provoking and challenges you, while also being beautiful and engaging. It causes you to ask questions.*** In another discussion, adding to this theme, another person commented that ***art should speak to something that is unnamable and that the worse thing an artist can be is pedantic.***

Participants seemed to agree that art is able to address issues in a different way than science is, noting, for example that ***imagery has more impact on someone than they realize and arts can help us model certain things... [such as] storytelling***, and that ***arts in general can bring people together... and do much what a church used to do or much what a school might have done***.

One participant who was also an artist acknowledged that they ***by no means think[s] art is any sort of savior***, which resonated with other comments by a neighborhood association member who felt art might be less important than dealing with crime and violence. Saying that, however this participant could see the value of arts within a community, stating that ***any strong community with strong relationships between community members and a strong sense of neighborhood-ness or pride... has a story to tell.... And I think that's where the arts are most valuable, in community building and promoting a sense of civic oneness or wholeness or group-ness for a community.***

Expertise

Expertise, both in conversational and didactic ways, were coded relatively frequently compared to other codes. Comments coded under these themes were mostly from the facilitators of the Art + Science Brainstorms, especially the scientists. However, we do note that audience members did contribute their own expertise too.

Expertise covered a range of topics, and was more often didactic than conversational. Didactic comments usually entailed a facilitator or a participant telling the group factual information about science, history, or even astronomy. These topics ranged from how to make a model volcano to discussion about the tallest mountains in our galaxy. They covered topics such as Darwin's history and findings, water overflow and the sewage system of Indianapolis, why we have seasons on the planet earth, what gravity is, wildlife in urban areas, and discussion about robotics. Expertise topics rarely covered topics around the arts.

Participant Engagement

Participation was voluntary and open to the public, so it is unsurprising that participants appeared to be interested and engaged in the conversations. There appeared to be a mix of reasons why people attended. Some just happened to be in the library at the time, some were concerned local residents, while others were friends or colleagues of one or more of the facilitators. None-the-less, conversations amongst participants and facilitators were very amicable and often included humor and sometimes attempts to relate to each other through expertise and place.

Each Art + Science Brainstorm was unique. They varied in size and composition of participants and facilitators. Discussions were unstructured and influenced by all members of the group.

For example, one participant, a member of a neighborhood association, attended as a concerned resident who was skeptical about putting energy into the state of the waterways when more pressing issues appeared to require attention such as crime and violence. ***With those kinds of concerns in my neighborhood, I don't know how concerned I am with waterways and recreation. I look at things like the IMA project or something like that and think, were putting lipstick on the pig. We have some very basic problems that are of more direct concern to me.*** Yet, recognizing their presence, this participant added, ***But I am always willing to learn.***

The conversation this person was present for coded 19 of the 23 times the "How can we help?" theme was coded overall. It surfaced deep conversations about the utility of art in helping neighborhoods and communities. Some participants recognized that art is not the sole answer, but that it can help communities in creating and owning a story of their past present and future. Others raised the issue of being weary about art projects, which attempt to cover up deeper more painful issues with superficial fixes. That participant raised the importance of holding space in communities for grieving and anger, and allowing those communities to acknowledge the difficulties they have without trying to gloss over them.

Participants and facilitators often tied the conversations back to themselves and made it relevant to their own lives. This often took the form of relating the conversation to their own experience with art and science, or by relating it to their partners, siblings, or children. For example, one Art + Science Brainstorm constantly referenced the participants' professional lives, as they were mostly teachers, and discussed their experience of combining art and science in the classroom.

StreamLines Programming Events

INTRODUCTION

StreamLines events have occurred over the course of 2016 in various forms. With no single event coordinator as part of the StreamLines team, artists and I/CaLL team members have taken their own initiative in creating events to promote their works. Due to the independence of team members, it has been difficult to keep track of all the events that took place. Where possible, these events were often orchestrated with the help of community organizer, Molly Trueblood, to ensure their welcomed and well-timed reception within the communities where they occurred.

Although events had nuanced focuses in the science and content they hoped to relate to the public, all events ostensibly addressed water sustainability on some level. How this greater umbrella focus was addressed depended on the event and facilitators present.

METHODS

Although a greater number of events occurred, NewKnowledge researchers and associate colleagues such as interns, collected surveys at the following events due to scheduling and timing constraints:

- Children's Museum Family Night
- Catherine Bowman Poetry Reading/Pogue's Run
- Butler Art's Fest Big Test Installation
- Catherine Bowman Poetry Reading/Fall Creek
- Alessandra Lynch Poetry Reading at the Canal
- White River Stream Walk

Survey questions were designed to assess science literacy growth by asking attendees about the science topics covered in each event. Surveys also assessed the event's effectiveness at teaching science topics, and the relationship between art and science.

Participants

A total of 83 participants completed event intercept surveys. The largest number of participants had attended either the Children's Museum Night (*n* = 22) or Catherine Bowman's poetry readings at Pogue's Run (*n* = 19) (Table 4).

Table 4. Surveys completed at StreamLines events in 2016.

Event	*n*	%
Children's Museum Family Night	22	26%
Catherine Bowman Poetry Reading / Pogue's Run	19	23%
Butler Arts Fest Big Tent Installation	13	16%
White River Stream Walk	13	16%
Catherine Bowman Poetry Reading/Fall Creek	10	12%
Alessandra Lynch Poetry Reading at the Canal	6	7%
Total (*N*)	83	100%

Most people heard about events either by word of mouth or through social media. See Table 5.

Table 5. How individuals heard about StreamLines events.

Source	*n*	%
Word of Mouth	28	34%
Social Media	17	22%
Passing by	6	7%
Flyer	2	2%
Radio	1	1%
Newspaper	1	1%
*Other	27	33%
Total (*N*)	82	100%

*Other sources for how participants heard of the event most frequently included through *the museum* (*n* = 9), *Butler University connections* (*n* = 6), and *through a friend* (*n* = 6).

Instrument

NewKnowledge researchers who were familiar with StreamLines created a short survey to assess science literacy growth by asking attendees about the science topics covered in each event. (see Appendix B). Surveys also assessed the event's effectiveness at teaching science topics and the relationship between art and science. Phrasing of survey questions were slightly altered to maintain relevance depending on the event but contained the same core questions.

Analytic Approach

NewKnowledge researchers used the social science statistical software SPSS to conduct quantitative data analyses, including descriptive statistics, frequencies, paired sample t-tests, and ANOVAs. When looking at qualitative questions, we used a coding process based in grounded theory methodology in order to determine if there was potential for science literacy growth and if the event had an impact on attendees' science literacy and knowledge.

Molly Trueblood conducted semi-structured interviews with a smaller group of event attendees to further assess science literacy gained through event attendance. These interviews elaborated on questions and responses in the survey, so they were not included in the data set. However, responses from those participants were consistent with the findings described below.

RESULTS

Science Literacy Growth in a Community

Surveys were distributed following a range of I/CaLL events around Indianapolis. Groups were too small to do adequate analysis to see if there are significant differences of impact between events.

Compiling responses across events, when asked what science topic was covered by the event most people believed it was *water or waterways* (*n* = 34). Many brought up *nature and ecology* in general (*n* = 19), while nine people specifically mentioned *riparian habitats*. *Threats to biodiversity* (such as pollution, climate change and endangered species) was brought up by ten individuals. Other mentioned topics included *human connection to nature* (*n* = 8), and *art* (*n* = 4). Four people did not know what science topic was covered by the event.

Overall, participants agreed the science topics covered in the events were relevant to their daily lives (see Table 6). Participants also felt the events were effective at communicating about science and helped them think about science topic in new ways (see Table 6).

Table 6. Beliefs about StreamLines events and science topics covered.

	N	*M*	*SD*
I think this event was effective at communicating about science	84	4.32	0.91
This science topic is relevant to my daily life	83	4.29	0.96
This event made me think about the science topic in new ways	84	4.20	0.98
This science topic made me think of the Indianapolis waterways in new ways	83	4.14	1.09

Notes. Responses were recorded using 5-point Likert type Scale measures, with; 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree. Data is based on all recorded responses (*N* = 84).

A paired sample t-test showed significant increases in the means of participants' competency after, compared to before (retrospectively), the event across all three prompts, with a significant p-value, < .05. Participants were significantly more likely to feel like art can be an effective way to communicate science ($p < .001$) after the event than before. Participants were also significantly more likely to understand the science topic described at the event ($p < .001$) and explain the science topic to another person ($p < .001$) after the event than before (see Table 7).

Of the 72 participants responding to the question "Have you heard of StreamLines?", slightly more than half responded *yes* (*n* = 42), while the remainder responded *no* (*n* = 30). A one-way ANOVA showed us that living within 1 mile, 5 miles, or 10 miles from an installation site did not have an impact on the chances of the respondents having heard of StreamLines.

When participants were asked if they had closely examined the installations around the city, responses were split quite evenly with a little less than half responding *yes* (*n* = 33, 46%) and the rest selecting *no* (*n* = 39, 54%). When asked what they thought about the installations, participants (*N* = 31) reported that the installation was about *water or waterways* (*n* = 15), the *human connection to nature* (*n* = 8), and a smaller portion mentioned *linking science and art* (*n* = 6). One responded they did not know, while ten described how they felt about the installation. Respondents were coded into multiple categories.

A one-way between-subjects ANOVA exposed that living in close proximity to the installations had no impact on responses to the four components of Q4 on the survey (see Appendix B). These are the same four components listed in Table 6.

Another one-way ANOVA showed that living in the map's shaded area had no significant impact on if community members had closely examined the installations before (see Q12, Appendix B).

Table 7. Participants perceptions before and after StreamLines events.

		Before		After		*df*	*t*	*p*
	N	*M*	*SD*	*M*	*SD*			
I feel like art can be an effective way to communicate science.	76	4.12	0.91	4.61	0.76	75	-4.96	<.001
I understand the science topic described here.	75	3.42	1.14	4.27	0.89	74	-7.32	<.001
I can explain the science topic described here to another person.	75	3.19	1.10	4.14	0.96	74	-9.12	<.001

Discussion

HOW DO ART EXPERIENCES PROMPT SCIENCE REASONING?

Both the Art + Science Brainstorms and StreamLines events reveal how observation, ideation, brainstorming and discussion may, at least in part, lay the foundation for increasing opportunities for science reasoning and building science literacy through the arts.

This work with artists and scientists shows us that they both share a culture and a code that has been historically excluded the public. Artists and scientists may see the world differently, but they both seem to struggle to communicate and share their visions in an accessible manner for people outside of their groups. Both tend to use language that may easily slip into jargon, and at times their cultures preserve a feeling of elitism and self-segregation. This exclusivity seems to be encouraged by each profession's structural framework: for artists this structure lies partially in the need to attract wealthy patrons or gallery representation, while for scientists it is need to publish and gain tenure in academia.

In the Art + Science Brainstorms and the StreamLines events, the public (including artists and scientists) was able to draw ties between art and science and begin to understand the process and work of both artists and scientists. Participants began or deepened a conversation both within their circles and among their community members around this intersection. These discussions can be viewed as gateways into a world in which juxtaposition can promote exploration and negotiation: where art and science, and different modes of knowing (such as emotion and intellect) come together to create a deeper understanding of our world.

Art + Science Brainstorms resulted in vibrant discussions around the diversity and nuances of intersections between art and science. These were not scripted discussions guided by facilitators to ensure desired outcomes; they were rich dialogues, each uniquely influenced by those participating in the conversations.

Although the value of art was often discussed at a general level, or in relation to promoting cohesion within a community, individuals often saw art as essential to creating a progressive society. Discussions clearly noted overlap between art and science and often raised the notion of how interrelated art and science really are. Participants were able to see art in science *and* science in art.

At this stage, the Art + Science Brainstorms appear to equally promote the idea that art experiences can prompt science reasoning, and the idea that science experiences can promote art reasoning (or creativity). As the conversations unfolded, the connections made between art and science increased for both participants and facilitators. That this phenomenon appears to be a two-way road enforces the notion that art and science can work together; not, as has often been the case, that art serves science or vice versa.

We note that similarities between the two disciplines were more often considered than differences. This pattern suggests a desire to diffuse the more widely held belief that art and science are incompatible. As the boundary between art and sciences becomes blurry, participants more clearly see how both disciplines are motivated by curiosity, inquiry, and creativity, through different approaches.

In cultivating this conversation and beginning to bridge the two disciplines, participants looked past their own ideas of what art or science is and start to see both as pathways to learning. They are able to see, not just how art can prompt science learning or how science can prompt art learning, but how the two can promote learning in general. The depth and quality of learning that can accrue from such a marriage is not clear from our data or previous research in the field. However, in embracing both disciplines as parallel means to learning that can become a unified discipline, one can imagine creating a deeper inquiry culture.

Participants not only thoughtfully considered the relationship between art and science, they also started to call upon faculties within themselves that are essential to both the arts

and the sciences. For example, both facilitators and participants in the Art + Science Brainstorms showed creativity in drawing connections between the arts and sciences, and exhibited curiosity and inquiry while using both inductive and deductive reasoning to consider the "other's" path to knowledge to support their arguments. Through inductive reasoning, they recalled past experiences to offer information that could highlight the overlap between art and science. Likewise, holding those inferences in hand, both participants and facilitators were then able to delineate different ways they believe art and science interact using deductive reasoning with their shared set of evidence.

Findings from the StreamLines events support these findings. StreamLines events often featured artists discussing their creative process and the way in which they worked with science content. Unlike the Art + Science Brainstorms, these events specifically discussed art created for StreamLines. Although participants were included in a conversation about art and science just like the Art + Science Brainstorms, they were further privy to specific science content and artistic process.

Participants' perceptions of the events showed that the events impacted their thinking about science. They felt strongly that the science topics covered in the events were relevant to their daily lives, and made them think about waterways, and other science topics, in new ways. We found that participants were significantly more likely to report understanding the science topics described at the event, feel they were able to explain those topics to another person, and see art as an effective way to communicate science after the event than before.

The events clearly impacted audience members in the intended ways, for both Art + Science Brainstorms and the StreamLines programming events. Further research should explore the longevity of learning outcomes, as well as impacts on surrounding communities.

HOW DO WE MEASURE AND DEFINE SCIENCE LITERACY GROWTH IN A COMMUNITY?

Both the Art + Science Brainstorms and StreamLines events begin to push our understanding of how we can measure and define science literacy growth within a community. While the sample size in this study is small, the results suggest opportunities for both research and developing interventions.

Based on the responses and level of engagement among participants and facilitators, public spaces where informal discussion around art and science can occur among community members and scientists / artists holds the potential for science literacy growth to occur. If art-science projects are able to create new knowledge within communities, these discussions may be the first step to complement learning the community already engages in.

Discussions such as these may act as a barometer and benchmark for community-wide science literacy in relation to art. If these public events can create fertile ground to expose the potential of art-science collaboration, then there is a good chance science literacy growth is occurring in these communities. People who participate in these dialogues will likely have diverse backgrounds and may very well impart their experiences to other community members who don't attend the discussions. In this way, the effects on science literacy might ripple through the community.

For example, one Art + Science Brainstorm was comprised of a number of art teachers and science teachers. These teachers were fascinated by the links between art and science and if their interest and curiosity are any indication, it is likely they will bring that conversation back to their classrooms. Children will be exposed to these ideas who may in turn expose their parents to them.

Additionally, libraries are an advantageous place to cultivate an art-science literacy initiative. Library public programming is increasingly playing a vital role in advancing community literacy (American Library Association, 2014). We believe this community literacy can equally include and promote science literacy. Creating partnerships between science learning programs and public libraries may be a strong way to increase the force of our education efforts.

Therefore, instances of public discussions such as the Art + Science Brainstorms or StreamLines events may act as a measure of science literacy growth within communities across the US. Further research and follow-up longitudinal studies are needed to explore this idea.

City-Wide Community Science Learning

Community dialogue events such as small group conversations and larger-scale performance or activity events impact public audiences in slightly different ways. In the case of this study, Art + Science Brainstorms as small-group dialogues offered an open-ended forum for members of the public to hold conversations about the similarities and difference between art and science in general. Meanwhile, StreamLines events featured existing art and science interventions concerning the waterways of Indianapolis.

Our findings indicate that general community discussion about art and science may act as a gateway to understanding the connections between art and science. This scenario offers the public a foundation from which to build a deeper understanding of how art can prompt science learning, or vice versa. Furthermore, discussions such as the ones in this study hold the potential to radiate throughout communities as participants continue to consider these connections with friends and family.

Having begun the conversation within the community, the public is now primed to receive and understand specific art and science interventions with more depth and clarity. In the case of StreamLines, Art + Science Brainstorms happened in parallel with the programmatic outreach events. We cannot say whether these discussions impacted the public's ability to learn from the programmatic outreach events. However, outreach events can take the general conversation of the Art + Science Brainstorms and make it tangible. Specific interventions can be discussed in local neighborhoods in ways that positively impact those who attend, conveying science topics in meaningful and digestible ways. In the future it may behoove projects to begin with community brainstorming discussion about art and science intersections before the interventions are created.

Conclusion

This study tested how two different approaches to engage the public in dialogue about how art and science increase understanding of a city's waterways: one approach featured an open-ended dialogue for a small group, and the other a performance or activity for a larger group. Both approaches were successful in engaging people in thinking about the relevance of science to their surroundings, as well as the deep connections between art and science. These results suggest that art can be a tool for engaging the public in dialogue about science, which is a recommended area for future research about science literacy at the community level.

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