



Evaluating the Impact of a Comprehensive Canadian Science-Art Residency Program on the Participating Scientist, Artist and the Public

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Specialty section:

This article was submitted to
STEM Education,
a section of the journal
Frontiers in Education

Received: 03 April 2021

Accepted: 12 October 2021

Published: 20 January 2022

Citation:

Lau C, Barriault C and Krolik J (2022)
Evaluating the Impact of a
Comprehensive Canadian Science-Art
Residency Program on the
Participating Scientist, Artist and
the Public.
Front. Educ. 6:690489.
doi: 10.3389/educ.2021.690489

Science-art residencies can provide opportunities for insightful cross-disciplinary collaborations, science communication, and engagement with the general public. Currently, there are few formal ways for artists and scientists to collaborate in Canada, and even fewer publications on how these experiences can impact learning in informal settings. Art the Science (a Canadian non-profit organization facilitating cross-disciplinary relationships between artists and scientists) piloted a comprehensive multiphase science-art residency program. Phase 1 informed the artist's work through a full-time experience in a scientific laboratory at an academic institution, Phase 2 showcased the artist's final artwork, *Between the Sand* at an off-campus local community event, and Phase 3 published an interactive online version of the work for global exhibition. Residency evaluation in each phase was conducted through the use of qualitative and quantitative methods, including interviews, concept mapping, video diaries, and surveys. The artist, scientist and lab members gained new perspectives and inspiration about their respective fields. The artist was able to incorporate theories and processes from the research group into their artistic practice. On the other hand, the scientist saw renewed enthusiasm and curiosity within their research lab, and the lab members reported new ways of thinking about how to communicate their research. Both exhibitions proved to be engaging informal learning experiences for 66.2% of survey participants, and revealed several major learning themes. Despite promoting both events as artwork exhibitions, 79.2% of survey participants considered *Between the Sand* as both an artwork and a science communication product suggesting that science-based art may have the potential to communicate science, even when it is not presented as a science communication effort. Public responses revealed that public perception of funding is not skewed to either discipline and instead seems to call upon both science and arts grants to fund such interdisciplinary initiatives. Providing comprehensive artist residencies in science labs may have a valuable impact on everyone involved: the artist, the research group, and the public.

Keywords: science-art, residency, science communication, collaboration, cross-disciplinary, SciArt

INTRODUCTION

Arts-based initiatives are growing as a favoured approach for science communication in formal and informal settings for the general public (Root-Bernstein et al., 2011). Part of the reason may be due to the nature of how art and culture can connect with people in ways that science cannot do alone (Van Riper, 2003; Kaiser et al., 2014). By reshaping narratives and allowing for different mediums of expression, art is not simply a vehicle for communication and understanding. It fosters a space that encourages questions, discussions, and actions around important societal issues, such as the case with climate change (Galafassi et al., 2018). Art can help facilitate storytelling, knowledge exchange and communication which is deeply needed for adults who spend most of their life outside the formal learning environment (Falk and Dierking, 2019). While the art and science culture (in terms of initiatives, programs, and experiences) in Canada has not advanced as far as that of the United States, United Kingdom, Europe, or Australia, the movement is steadily growing and supporting a space for science-art partnerships and experiences (Zaelzer, 2020).

Interactions between art and science can take many forms and are not limited to collaborations like artist residencies, exhibitions, and outreach events. In fact, the interface between these two disciplines garners many labels including ArtScience (Schnugg, 2019), A&S (Sleigh and Craske, 2017), science-art, SciArt, ArtSci, Sci + Art, STEAM (Science, Technology, Engineering, Art and Math), and Science*Art (Stevens et al., 2019). There are also specific practices such as “BioArt”, which use techniques and tools in science to make art with the intention of challenging science (Sleigh and Craske, 2017), as well as domains dedicated to the link between art, technology, culture, and society (e.g., Ars Electronica, Milieux, MIT-ADT).

Most notably, the term “SciArt” has been growing since the beginning of the 21st century and continues to be used increasingly on social media (for example, #SciArt and #SciArtTweetStorm on Twitter) and in popular science magazines (former Sybiart blog on Scientific American). It is also worth noting that the term gained significant momentum thanks to branding of the Wellcome Trust’s “Sciart” programme (in the United Kingdom) which provided grants for projects at the intersection of art and science in the late 90s to the early 2000s (Glinkowski and Bamford, 2019). While science communicators and many who practice or work in between the disciplines of art and science may celebrate this term, some hold the opposite disposition, expressing disdain for a branding label that limits and segregates artists by using the visual arts in service for the sciences (Sleigh and Craske, 2017).

If we are to truly foster meaningful relationships between artists and scientists, it is important for both disciplines to be valued. While art can be a communication vessel for science, it can go far beyond this to create discussion, to challenge, to entertain, and to inspire. Including art in science communication or science engagement initiatives is certainly valuable, however we argue that scientists and science communicators should recognize that the art-science interface can and does go beyond simply communicating science to public audiences.

Artist residency programs typically invite artists and other creative professionals to step away from their usual work environments and into a space (usually within an institution) for some time to reflect, do research or produce art. Residencies vary from place to place, with some having a clear focus on the collaboration process, while others offer opportunities to create new artwork based on their experience (Schnugg, 2019). These experiences can provide opportunities for cross-disciplinary collaboration between artists and scientists and can take place within organizational structures (e.g., universities, research centres, companies). Some notable international artist residencies at scientific institutions include Arts at CERN and SymbioticA. In Canada, there have been a handful of artist residencies in dedicated scientific spaces, including Perimeter Institute, University of Guelph (School of Environmental Sciences), Ayatana, Convergence Initiative, the MOCA/OSC residency (Museum of Contemporary Art and Ontario Science Centre) and SNOLAB.

While cross-disciplinary collaborations and programs are increasing, documentation and evaluation of such projects is sparse, and perhaps for good reason. There is no doubt that there is an interest in art-science projects from diverse disciplines, however the outcome can be challenging to evaluate. It can also be difficult for either the artist or the scientist to get recognition for their contribution in their own discipline, and there are barriers to integrate projects within their disciplinary careers (Schnugg, 2019). Additionally, there may be other problems that arise, such as who is responsible for the evaluation, what the purpose of the evaluation is, as well as the availability of time and resources to conduct it.

Arguably the most thorough and large-scale evaluation of science and visual art collaborations is the Wellcome Trust’s Sciart programme which spanned a decade from 1996–2006. It supported 118 projects amounting to nearly £3 million in grants with the primary intention of fostering interdisciplinary practice in art and science and engaging the public (adults) in the biomedical sciences. The evaluation consisted of case studies, interviews, surveys, audience tracking, and focus groups to determine emerging themes. Overall, the Sciart programme received mostly positive feedback from artists, scientists, and the general public. Interesting themes that emerged from the evaluations included: 1) Some artists reported an improvement of career opportunities, as they were able to elevate their profile and secure exhibiting or commissioning opportunities; 2) Most scientists reported an improvement in their communication skills and felt more comfortable engaging with the public, and 3) Art opened the scientific practice to a broader audience and made science more accessible. However, the collaborations did not go without challenges. Some artists felt they were more involved than their scientist collaborators, while some scientists felt it was difficult to justify such interdisciplinary collaborations that did not contribute directly to advancing their discipline (Glinkowski and Bamford, 2019).

Examples of enhanced public engagement through art and science collaborations have also been documented through science outreach programs (Drumm et al., 2015) and festivals (Beakerhead, 2017; Rosin et al., 2019). In addition, fields such as

environmental science and ecology have seen an increase in support for arts-based initiatives to promote awareness and discussion around climate change and the environment (Galafassi et al., 2018; Stevens et al., 2019; Brault, 2020).

Other approaches have also been used to evaluate or explore art and science initiatives. For example, to better understand the artist and scientist collaboration process, Halpern (2011) provided prompts about the boundaries of art and science to artist and scientist pairs who were then observed on how they engaged with their tasks. Interestingly, other research groups have gone beyond traditional qualitative measures of evaluation (such as interviews and focus groups) to create a new psychosocial framework to measure the aesthetic experience of art-science works, which aims to provide a deeper examination of what specifically occurs at the intersection of art, science, and the public (Muller et al., 2015).

Comprehensive evaluations that include an assessment of the process of art and science collaborations, as well as their impact on public engagement with science, remain low in number. Furthermore, much of the current research and reporting comes from the United Kingdom (Drumm et al., 2015; Glinkowski and Bamford, 2019), Europe (Schnugg, 2019), Australia (Muller et al., 2015) and the United States (Rosin et al., 2019). While there are Canadian art and science initiatives, few have the capacity to implement a formal evaluation. Some question the need for formal evaluations given their contexts, such as galleries and maker/creative spaces where informal feedback (short surveys or speaking to clients) is sufficient for improving future programming (Lau, 2016). However, the art and science (or science-art) culture is growing in Canada through aforementioned organizations and programs/initiatives. It is therefore becoming more important to document, assess, and report on the processes, impacts and ultimate value of such art and science initiatives.

Art the Science (ATS) is a Canadian non-profit organization facilitating cross-disciplinary relationships between artists and scientists to encourage scientific knowledge exchange with public audiences through artistic means. ATS developed a three-phase comprehensive science-artist residency program designed for research institutions (e.g., academia, government) and their scientific researchers. The goal of the residency is to help bridge the gap between research scientists in academic settings, artists interested in science, and the public, who typically have very little access to scientific research. The residency enables the artist to expand their practice in a scientific environment giving the artist access to scientific methodology, tools and concepts often not accessible to artists. The artist has an opportunity to learn and hone novel scientific methodologies, which they can apply in other areas of their work. Finally, by fully integrating into the research group on a full-time basis for several weeks, the artist gains a valuable network of scientists which can lead to opportunities in other research groups.

The research group has an opportunity to view their work in a different light by hosting someone from a different field of expertise. Interactions with the artist may lead the scientists to new perspectives and novel paths of discovery. In addition,

artwork created by the artist during the residency will help the research group share elements of their science in a new way with public audiences.

For members of the public, the benefits from this residency are twofold. One of the phases of the residency provides an opportunity for the local community around the institution to engage with the scientist, the artist, and the artwork. The other phase engages the global community at large via an online interactive artwork hosted in Art the Science's online Polyfield Gallery. An online experience, when developed with accessibility in mind, has a much greater reach than an exhibition on gallery walls. The interactive component allows for exploration and engagement.

An environmental engineering research laboratory at Queen's University in Kingston, Ontario, Canada was selected because Dr. Kevin Mumford (henceforth "scientist") expressed interest in exploring creative initiatives with his research group. The group's research focuses on understanding the trajectory of hazardous chemicals when they are discharged into the environment, as well as the remediation of contaminated sites. The group's research projects range from experiments that mimic how liquids and gases move through porous mediums to computer models of those processes.

To pilot the residency program, Art the Science recruited Owen Fernley (henceforth "artist"), an artist who has previously exhibited work with Art the Science. The artist uses creative coding to create artworks. Therefore, his artistic practice complemented the computer modelling research in the scientist's laboratory and provided the artist with a wide range of ideas and data to work with for his creative coding practice. The artist was also recruited to pilot the residency because he had formal training in science prior to becoming an artist, which allowed Art the Science to determine how much the artist relied on his training to navigate a scientific field that was novel for him. The scientist provided in-kind support as well as an artist honorarium for the residency which the artist donated to Art the Science to host the Phase 2 event.

Phase 1 took place on March 19–30 in 2018. During this phase, the artist became an active independent member of the research group on a full-time basis for 2 weeks. He received relevant safety training and was assigned a desk in the research group office space. He participated in all research group meetings and also met regularly with the scientist. The artist was immersed into the research process, from observing experiments to working alongside graduate students. He learned about the different experiments happening in the lab and eventually decided to focus on the research of a specific Ph.D. student for his creative inspiration. He also showcased his artistic practice to the research team by giving a talk and created a preliminary research-based artwork to demonstrate his artistic direction with this project. The artist chose the title *Between the Sand* for his work and completed the first iteration for display in an art gallery after Phase 1.

Phase 2 occurred on February 27th in 2019. It was important to select an art gallery space outside of the academic institution where the scientist conducted his work in order to encourage maximum local community interest and attendance. Art the

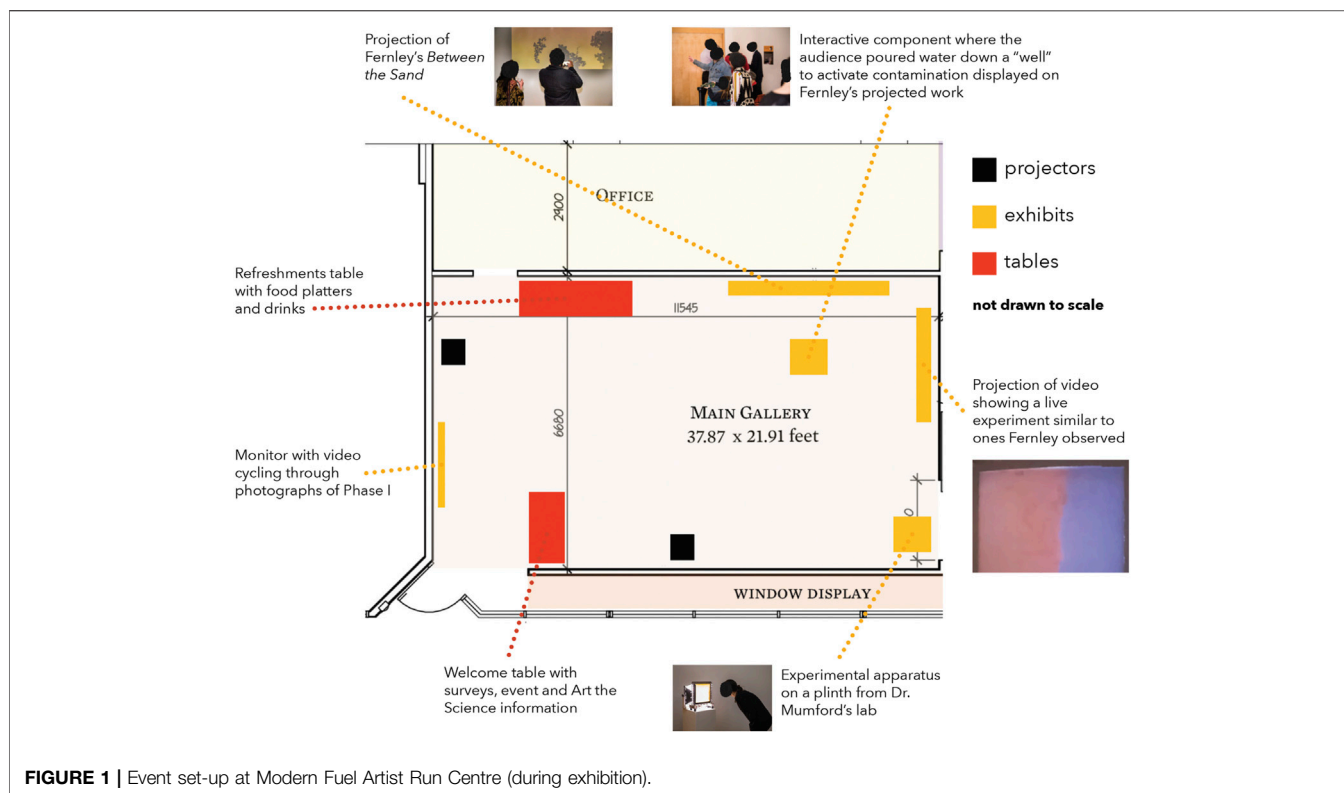


FIGURE 1 | Event set-up at Modern Fuel Artist Run Centre (during exhibition).



FIGURE 2 | Event set-up at Modern Fuel Artist Run Centre (during panel discussion).

Science chose a non-profit artist run centre space called Modern Fuel, located at the Tett Centre, the city of Kingston's hub for creativity and learning.

The event was promoted through various municipal channels including: an article in the local paper, an interview on campus community radio, use of Facebook ads targeting local audiences, and many event listings across various local websites.

The exhibition included projections of both the artist's work and a looping video footage of an experiment, a looping montage of Phase 1 photos displayed on a wall-mounted monitor, and a backlit experimental apparatus displayed on a

plinth (**Figure 1**). This setup was altered to accommodate a row of chairs at the front and audience seating for the panel discussion (**Figure 2**).

This Phase 2 version of *Between the Sand* consisted of a wall projection showing digital contamination between sand grains. The contamination would be activated when water was poured down a plastic pipe resembling a well and picked up by a piezo sensor hidden inside. This version of *Between the Sand* had the following artist statement:

"We are all living on the surface of a permeable planet. What goes up must come down, but perhaps more disconcerting, is what goes in.

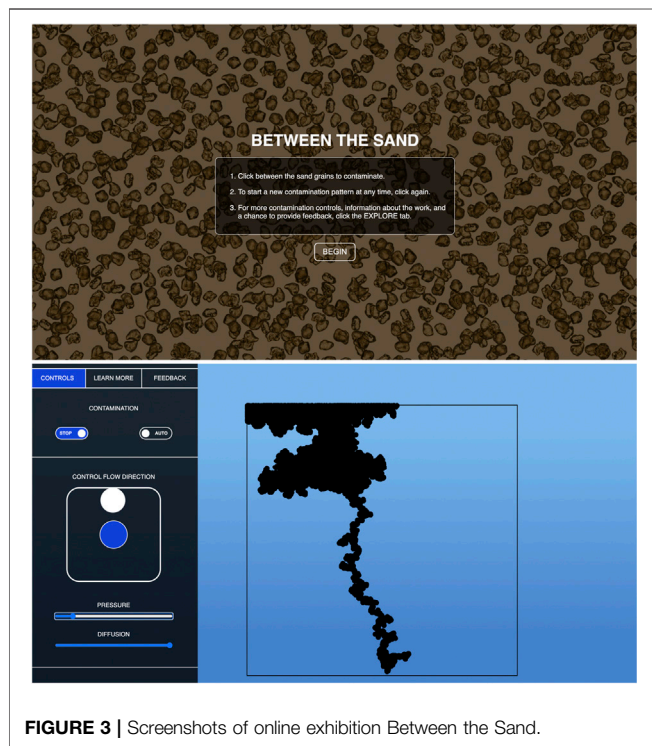


FIGURE 3 | Screenshots of online exhibition *Between the Sand*.

When chemicals like gasoline, creosote and PCB's are improperly disposed of or spilled, they leach into the ground and contaminate our soil and groundwater, spreading out below us in unseen ways. Pollution does not simply flow through the ground the way it does on the surface. It is under pressure and moves through very small spaces. Understanding this movement can be challenging and leads us to an important series of experiments designed to inform how we might model this movement in the future.

When sand is compressed between two panes of glass, intricate maze-like pathways are formed between each grain. This is the space between the sand. The resulting sections are only 14 grains deep, yet gases, fluids and pollutants move through them in many surprising and beautiful ways. Observing this movement provides scientists and engineers with the data they need to predict and prevent the spread of underground contamination, as well as develop technologies to clean it up.

Between the Sand is an interactive computer program that invites us to explore how our actions affect the ground beneath our feet. It builds a maze of pathways between grains of virtually generated sand. Initiated by the viewer, the maze is “solved” using Invasion Percolation, an algorithm infamous throughout the research group for only following predetermined pathways. In *Between the Sand*, this algorithm is used to present a relationship between direct human action and our unseen subterranean environment. And with that, we can observe the unobservable.”

The discussion panel consisted of the artist, the scientist, the Ph.D. student whose work inspired the artist, Art the Science’s program evaluation officer and was moderated by Art the Science’s executive director. This component helped the audience go behind the scenes of the residency and also

learn about the inspiration and the making of *Between the Sand*. A lively discussion with the audience followed the panel.

Phase 3 was launched online on December 5th in 2020. To share this work with audiences around the world, the artist programmed and optimized *Between the Sand* specifically for the web to create an interactive online experience (Figure 3). The artist created a digital control panel where visitors can make custom adjustments to the artwork. Some of the options mimic experiments the artist observed in the lab and others are derived from his creative coding experience in making the work (Figure 3).

This paper reports on a study that explored the implementation and impact of a novel, three-phase artist residency approach facilitated by a non-profit organization in a scientific research facility. The three phases of the residency are: 1) In the Lab, 2) Local Sci-Art Exhibition Event and 3) Online Interactive Sci-Art Exhibition. This study investigated each phase in order to document and evaluate the impact of the artist residency. The investigation was guided by the following research questions:

Phase 1. What is the value of a science-based artist residency to both the artist and the science research group? How do the artist, scientist, and lab members benefit, or not, from this interdisciplinary experience?

Phase 2. What are the opinions, perceptions and impressions of the attendees at the Local Sci-Art Exhibition Event regarding art and science collaborations and the resulting work of art?

Phase 3. What are the opinions, perceptions and impressions of the virtual attendees at the Online Interactive Sci-Art Exhibition regarding art and science collaborations and the resulting work of art?

METHODS

Phase 1 Evaluation

This evaluation assessed the value of a science-based artist residency to both the artist and the research group, as well as how both the artist and scientist could benefit, or not, from this interdisciplinary experience. In their review of science communication through art, Lesen et al. (2016) recommended using pre/post interviews for evaluating scientist-artist collaborations. Thus, this evaluation of the value of this residency included: 1) pre- and post-residency interviews with the artist and scientist, 2) daily video diary entries from the artist and 3) interviews with lab members following the residency.

Interviews

Both artist and scientist agreed to participate in pre- and post-residency interviews, which would help document their perspectives in both time frames. Due to time constraints and availability, lab members were not asked to participate in an interview prior to the residency. However, they were invited to take part in an interview following the residency. Four lab members agreed to participate. Interviews were semi-structured and took place via Skype video calls for 30–45 min.

See **Supplementary Information SA–SC** for interview questions for the artist, scientist and lab members respectively.

Reflective Concept Map

One component of the pre- and post-residency interviews was a reflective concept mapping exercise that is similar to a brainstorming activity, where an individual writes down relevant ideas pertaining to a topic or prompt. In this case, both artist and scientist were asked to write down ideas that came to mind with the prompt: The value of an artist in a science community. This exercise complemented the interview, as it allowed for an alternative way of reflection and expression of ideas. It provided both artist and scientist time to think freely and to document their ideas on paper instead of responding to questions one after the other.

To provide ample time for participants to develop their reflective concept maps, templates and instructions were sent to the participants prior to the interview. Participants were asked to take about 5 min to jot down ideas and thoughts that came to mind in response to the aforementioned prompt. Concept maps were then sent back to the interviewer and to be later discussed in the interview in more detail. Due to constraints of availability and in an effort to encourage more lab members to participate in a short post-residency interview, the concept map component was not implemented. Instead, an interview question about an arts-based approach to communicate science was asked.

Daily Diary

The artist kept a daily video diary to document the progress and the day-to-day experience during the residency. These entries were made at the end of each day and guided by the following set of questions:

- 1) What were your goals today?
- 2) What did you learn?
- 3) What were you surprised about?
- 4) What were your challenges?

Data Analysis

Audio for the interviews was recorded and transcribed manually by the interviewer. A thematic analysis was conducted for both interview responses and reflective concept maps (**Tables 1–3**).

Phase 2 and 3 Evaluation

To evaluate attendee reception of *Between the Sand* at Modern Fuel, a survey was conducted during the event (**Supplementary Information SD**). Participants were approached by an ATS team member with a clipboard and asked if they wanted to participate. If they agreed, they were asked to review an informed consent form prior to completing the survey. Responses were collected using paper surveys on clipboards and manually entered into a secure online form after the event. This evaluation method was integrated into the event with the host providing context for the survey and encouraging attendees to participate several times throughout the evening. In addition, two ATS members approached attendees with clipboards to make completing the survey as convenient as possible.

A survey (**Supplementary Information SE**) similar to the one used in Phase 2 was conducted online to evaluate *Between the Sand* as a digital exhibition for Phase 3. The survey was linked directly from the work under a tab titled “FEEDBACK” (**Figure 3**) and the results were collected using a secure online form. Participants were recruited by sharing the artwork, mentioning the survey on social media channels, and sharing with relevant networks asking them to proliferate the call for artwork viewing and study participation. Survey responses from Dec 9th to Feb 18th, 2021 were included in this study.

The survey included likert scale questions and open-ended responses. The likert format questions and answers are in **Table 4**.

Phase 2 and 3 Data Analysis

Microsoft Excel (365 for Mac) was used to code, analyze, and visualize the data for both Phase 2 and 3. For the open-ended questions, a thematic analysis was used to capture emerging themes from the participant responses. The number of comments which fell under each theme were documented, along with sample quotes (**Tables 5, 6, 7**). Cronbach alpha was calculated for each survey section with three or more statements using the same agreeability scale to determine internal consistency.

RESULTS

Phase 1—In the Lab Pre-Residency Interviews

The thematic analysis of the Phase 1 pre-residency interview data revealed the common sub-themes (**Table 1**) for both the scientist and the artist under themes of: personal interests, opportunities for engagement, and the value of an artist in the science community.

The pre-residency interviews revealed many common interests between both artist and scientist, despite their different lines of work. The artist used physical algorithms to model real world applications in his visual/audio artwork, while the scientist used computer modelling in his research to better understand where contaminants go in the natural environment. For the artist, the residency was an opportunity to see how he could incorporate a research-informed algorithm in his line of work, whereas the scientist was looking forward to making his research more accessible to the public.

Both the artist and scientist described the limitations in their respective fields to connect and collaborate with people outside their fields for different reasons. The artist spoke about the lack of non-commercial opportunities in the art industry, while the scientist described the challenges to do outreach given their career priorities to advance research in their discipline.

Both the artist and scientist listed “new perspective” as their first thought when considering the value of an artist in the science community. They both described how an artist’s insight could inspire others in a scientific environment. The artist related this to a story of how humans in space were able to see a phenomenon that robots would not have been able to identify, showing the importance

TABLE 1 | Pre-residency interview.

Theme: Personal Interests	Theme: Opportunities for engagement	Theme: Value of artist in science community
Sub-Themes <ul style="list-style-type: none"> • Science / Technology • Algorithms • Real-world applications • Computer modelling 	Sub-Themes <ul style="list-style-type: none"> • Few opportunities and incentives 	Sub-Themes <ul style="list-style-type: none"> • New perspective • Inspiration • Knowledge translation • Better problem solving

TABLE 2 | Artist diary.

Daily Question: What were your goals today?	Daily Question: What did you learn?	Daily Question: What were you surprised about?	Daily Question: What were your challenges?
Themes <ul style="list-style-type: none"> • Engage with all lab members • Gather context (information on research projects) • Focus on artwork ideas • Create progress pieces to share 	Themes <ul style="list-style-type: none"> • Complexity of different research projects • Amount of control needed in experimental environment • Trial and error with coding 	Themes <ul style="list-style-type: none"> • Importance of safety in the lab • Academic structure is well oiled • Lab members open to playing with experimental set-up • Researchers can take tools they have for granted • First development of artwork 	Themes <ul style="list-style-type: none"> • Time constraints • Identify what research was available • Understanding the research • Find focus of the artwork • Ensure no missed opportunities

TABLE 3 | Post-residency interview.

Theme: Overall experience	Theme: Value of artist in science community
Sub-Themes <ul style="list-style-type: none"> • Positive • Many learning opportunities 	Sub-Themes <ul style="list-style-type: none"> • New perspective • Improving communication skills • Prompts discussion and engagement

of what a new perspective could bring. On the hand, the scientist voiced how creativity could be enhanced with the presence of an artist and help graduate students think differently about their work, creating a chain reaction of knowledge exchange in and out of the lab.

Interestingly, the concept map reflection allowed the scientist to acknowledge how creative scientists can be, and how much creativity is needed in the world of research. Despite this realization, there was some questioning as to whether or not the scientist's research group would be able to clearly communicate their research to people outside their area of study. In the artist's final reflections of the concept mapping, the artist thought about the possibilities of what society could learn if more cross-disciplinary experiences were implemented in research grants.

For other sub-themes that emerged from both the artist and the scientist, see **Supplementary Information SF**.

Artist Diary

The artist described the first few days as busy and information heavy compared to the rest of the residency. This included

undergoing safety training, learning about ongoing research projects, ensuring that he engaged with lab members and preparing a talk about his art practice to the research team. The artist noted the importance of reading through relevant journal articles to have meaningful conversations about the research, despite how challenging this was.

He started to connect with more of the lab experiments than the modelling work but was confronted with the conflict of data accessibility by the end of the first week. The artist described that one of his biggest challenges was figuring out what data he could use, while still providing his own angle. By the beginning of the second week, he shared his intention to focus on the topic of negative space and started learning how complex the modelling was. The artist noted he had more independent study time during the second week, which he used to experiment, and initiate artwork drafts informed by what he learned. Despite spending time on his own work, the artist was still able to encourage lab members to play with their experimental set-ups.

A summary of themes derived from the artist diary can be found in **Table 2**.

Post-Residency Interviews

The thematic analysis of the Phase 1 post-residency interview data revealed common sub-themes (**Table 3**) for both the scientist and the artist under the following themes: overall experience and the value of an artist in the science community.

The residency provided a two-way knowledge exchange, which was positively received by the artist, scientist and lab members. The participants described many learning opportunities which would not have occurred if it were not for this experience. For example, the artist shared his art form, creative coding, with the research lab, which was very different

TABLE 4 | Summary of in-person event survey responses, $n = 22$.

Question	Artist	Scientist			Other
Which of the following best describes you?	7	7			8
Question	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree
The interaction between artists and scientists can have societal benefits.	1	—	1	—	21
This event was an effective and engaging way to bring art and science together.	1	—	1	6	15
The panel discussion contributed to my understanding of the artwork (5 responders answered N/A because they didn't attend the panel)	—	—	—	7	10
I learned something new from this artwork	—	—	5	6	11
Question	Artwork	Science Communication Product		Both	
Between the Sand is?	4	2		16	

TABLE 5 | Themes of open-ended responses from event (only 16/22 chose to respond)^a.

Question: What did you learn from this artwork?		
Theme	Number of comments	Comments Examples
Art medium related	4	<i>"A new perspective on using code as a means of communication"</i> <i>"A new form of art"</i>
Research related	4	<i>"Learned about how we can have models for percolation/diffusion and that these models are being used to examine bitumen effects in soil."</i> <i>"More about the potential for groundwater contamination"</i>
Value of art and science	4	<i>"Verified that collaboration between science and art opens new doors"</i> <i>"The real world (of science) offers unlimited potential for artistic interaction."</i>
Value of process	4	<i>"It made a process visible which makes me look differently at the material"</i> <i>"Re-affirmed the process is as important as the product"</i>
Question: How could this event be improved?		
Theme	Number of comments	Comments Examples
More context needed	12	<i>"More context for the art in the section of the event before the panel discussion. Maybe a large poster like those on the wall at the beginning of a section of a gallery"</i> <i>"Information packets/descriptions for people to read about the projects. Provide context and background"</i>

^aSome responses were included in more than one theme, and/or some respondents did not leave comments, therefore total comments will not be equivalent to number of participants.

from the presentations the students were used to. For some students, it expanded their knowledge about how their research could be visualized and communicated.

Another important theme that emerged from both scientist and lab members was that they found it helpful the artist had some science background, as they believed it made communication and understanding a smoother process. However, the scientist described that while it was helpful for the artist to be able to follow along with the research, it did not necessarily elicit the need for the research group to simplify and therefore improve their communication style. For the artist, the experience in the lab brought many learning opportunities and inspiration for his work, but not without trial and error. The artist's initial ideas for the artwork changed immediately once he got a better understanding of the type of research that was done in the research lab.

For the artist, the greatest challenge was coming up with an angle for his artwork and figuring out what he could contribute. He described how it did not necessarily have to be a groundbreaking contribution, instead, it could be a unique contribution inspired by the ideas and knowledge that were learned during the experience. For the scientist, the logistics and planning of the residency were the hardest part in order to accommodate the artist.

The reflections for concept mapping following the residency were drawn from more concrete examples that both the artist and the scientist experienced. The artist commented on the importance of suggestion while observing experiments. He found that graduate students were quite open to his suggestions and it allowed them to see their experiments in a different light. The scientist saw that having an artist in the lab started to take effect on the ways his graduate students started to

TABLE 6 | Learning themes from online exhibit survey (only 53/55 chose to respond)^a.

Question: What did you take away from this online exhibit?		
Theme	Number of comments	Comments Examples
Visual aesthetic/entertaining	14	<i>"I was mesmerized by the visuals and found the experiment very interesting because it is something I'm unfamiliar with." "The beauty that is compressed gas and sand! I was engaged with the colour options and the flow patterns. Very beautiful!"</i>
Research/science related	20	<i>"Gas/water diffuse differently between different grains of sand, which impacts how watersheds change their landscapes in sandy settings." "Experiments using sand can help us better understand how fluids move through porous materials."</i>
Value/impact of bringing science and art together	20	<i>"Art can express scientific research in interesting ways and possibly help scientists look at their own work with a fresh perspective." "It's really fascinating what happens when someone who isn't the researcher engages with scientific research and presents it through a new perspective. I think for a lot of science communication that distance from the research is important to effectively share the work with new audiences, and <i>Between the Sand</i> is a great example of this."</i>
Uncertainty	4	<i>"I'm not sure what I was supposed to take away from the exhibit, but it was pleasant to watch." "It is fun but I'm still left wondering more about the purpose of this research."</i>

^aSome responses were included in more than one theme, and/or some respondents did not leave comments, therefore total comments will not be equivalent to number of participants.

TABLE 7 | Areas of improvement from online exhibit survey (only 50/55 chose to respond).

Question: Is there anything that would have made this online experience better?		
Theme	Number of comments	Comments Examples
Providing more context	14	<i>"Maybe more context about why this is important or how it's related to natural environments" "The "learn more" section is very detailed and informative, but it might benefit from some kind of concluding section that helps the user understand what it all means practically"</i>
Technical components (User experience)	24	<i>"An option to change the size of the sand grains would have been nice—smaller grains would make the diffusion patterns more delicate" "Maybe some audio component? Sole aspect that speeds up or slows down as the fluid reaches new cavities or barriers"</i>
Questions/Needed clarification	4	<i>"Could different coloured contaminations mean different things. could the contamination linger longer (and not leave) and what would that mean?" "I wonder why scientists are studying this? Why do they need to predict how gases will travel through porous media?"</i>

approach their research communication, such as the importance of a balanced colour palette when creating a data visualization. In addition, the scientist shared that his sentiments about the value of an artist in the lab pre-residency remained the same post-residency, including the increase of communication, accessibility, and knowledge sharing.

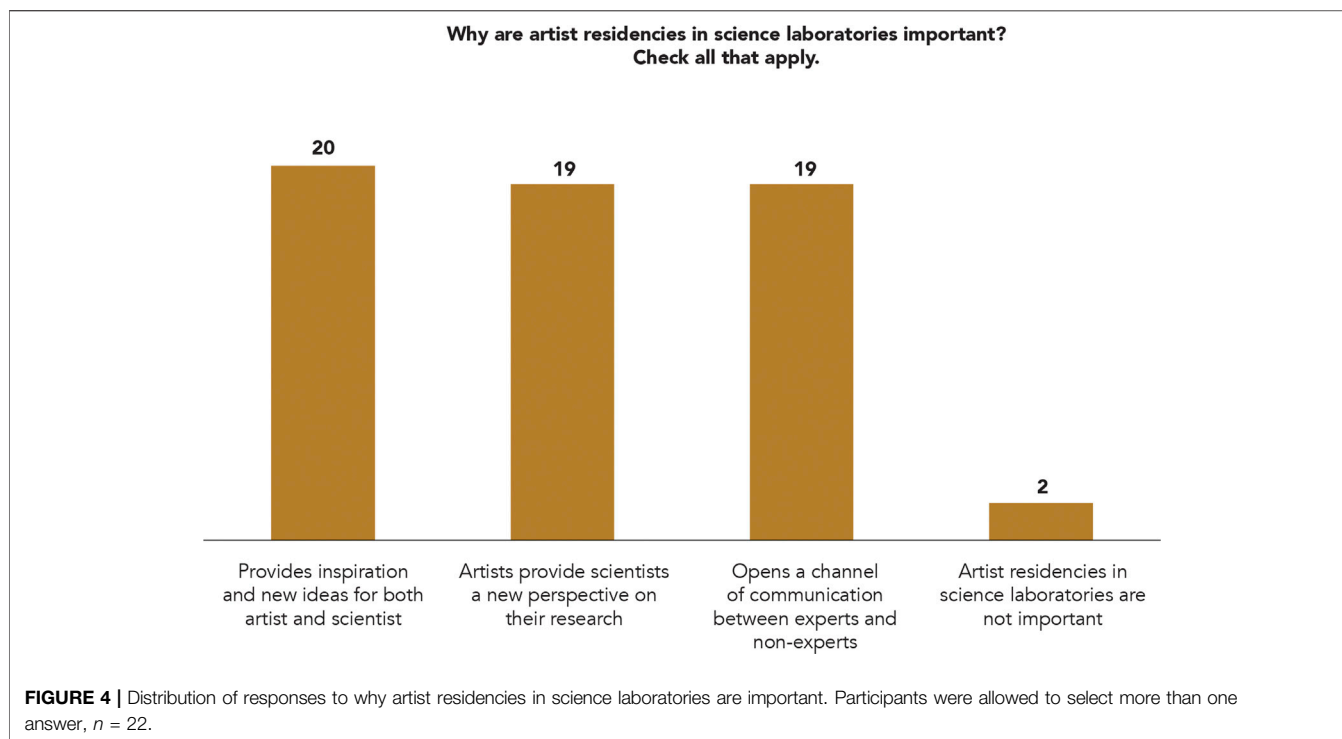
For other themes that emerged from the interviews, **Supplementary Information SG**.

Phase 2—Local Event

An estimated 35 people attended the local event. Twenty-seven individuals were present during the art exhibition panel session not including ATS team members or panelists. Integrating the survey into the event seemed to increase the survey response rate, which resulted in 22 completed surveys. Cronbach's alpha for

three statements using the same likert scale were calculated to be 0.53.

Attendee backgrounds included seven artists, seven scientists and eight individuals that had a different background or a combination of the two. Ninety-five percent (21/22) of the attendees strongly agreed that the interaction between artists and scientists can have societal benefits. In addition, 95% (21/22) agreed that this local event was an effective way to bring art and science together. Seventy percent (17/22) learned something new from the artwork. When asked to decide whether *Between the Sand* was an artwork or a science communication product, 73% (16/22) of the participants responded that it was both (**Table 4**). In addition, participants responded that artist residencies in science labs are important because: they provide inspiration and new ideas to the scientist and artist (20/22), the artist provides the scientist with a new perspective on their research



(19/22), and it opens a channel of communication between the expert and non-expert (19/22) (**Figure 4**).

According to participant responses, art grants (20/22), science grants (18/22) and universities (15/22) should be the main funders of artist residencies in science labs (**Figure 5**).

Answers to open ended questions were provided by 16 participants. Four themes emerged in response to “What did you learn from this artwork?”. The first was about the artwork medium where four participants commented on *Between the Sand* using a new artistic medium—creative coding. The second theme related to research where four participants commented on learning about the science undertaken by the research group. Another theme explored the value of art and science together with four participants expressing a positive association when science and art are combined. Finally, the theme of valuing the process also emerged with four participants noting that they valued learning about the process behind the research methods (**Table 5**).

Requests for feedback on improving the event revealed that (according to 12 participants) more context was needed to frame the residency program and artworks on display (**Table 5**). Suggestions included more informative signage at the entrance and perhaps a handout/program would have helped with providing more context. Two participants mentioned that more gallery space would have improved the event.

Phase 3—Online Exhibition

A total of 55 responses were submitted between Dec 9th and Feb 18th, 2021. Most of the participants were artists (14/55) and scientists (17/55) with 24 individuals identifying a different background than the aforementioned. Participant age ranges

fell into four categories: 20–29 (17/55), 30–39 (22/55), 40–49 (11/55), and Over 50 (5/55). Cronbach’s alpha for five statements using the same likert scale were calculated to be 0.77.

Survey responses revealed that 83.6% of the participants enjoyed the online exhibit (29 somewhat agreed, 17 strongly agreed, $n = 55$) and, 61.8% learned something new from the exhibit (16 somewhat agreed, 16 strongly agreed, $n = 55$). The majority (85.5%) of participants agreed that the online exhibition was an effective and engaging way of bringing art and science together (27 somewhat agreed, 20 strongly agreed, $n = 55$), 70.9% of participants would recommend the exhibit to a friend (18 somewhat agreed, 21 strongly agreed, $n = 55$) and only one participant had technical difficulties during their online experience of *Between the Sand* (**Table 8**).

Survey responses indicated that 81.8% of participants thought that *Between the Sand* was both an artwork and a science communication product (45/55). According to participant responses, science grants (49/55), art grants (46/55), and universities (43/55) should be the main funders of artist residencies in science labs (**Figure 6**).

A total of 53 participants (out of 55) provided comments on what they learned from the online exhibit. Most participants commented that they learned more about the research and/or the impact of bringing art and science together. Twenty comments were placed under the research/science related theme, which took into account concepts such as algorithms, gas diffusion, and contamination. Twenty comments were also included under the theme of the impact of bringing art and science together, which mainly included comments around how art and science can provide new perspectives and knowledge accessibility to the

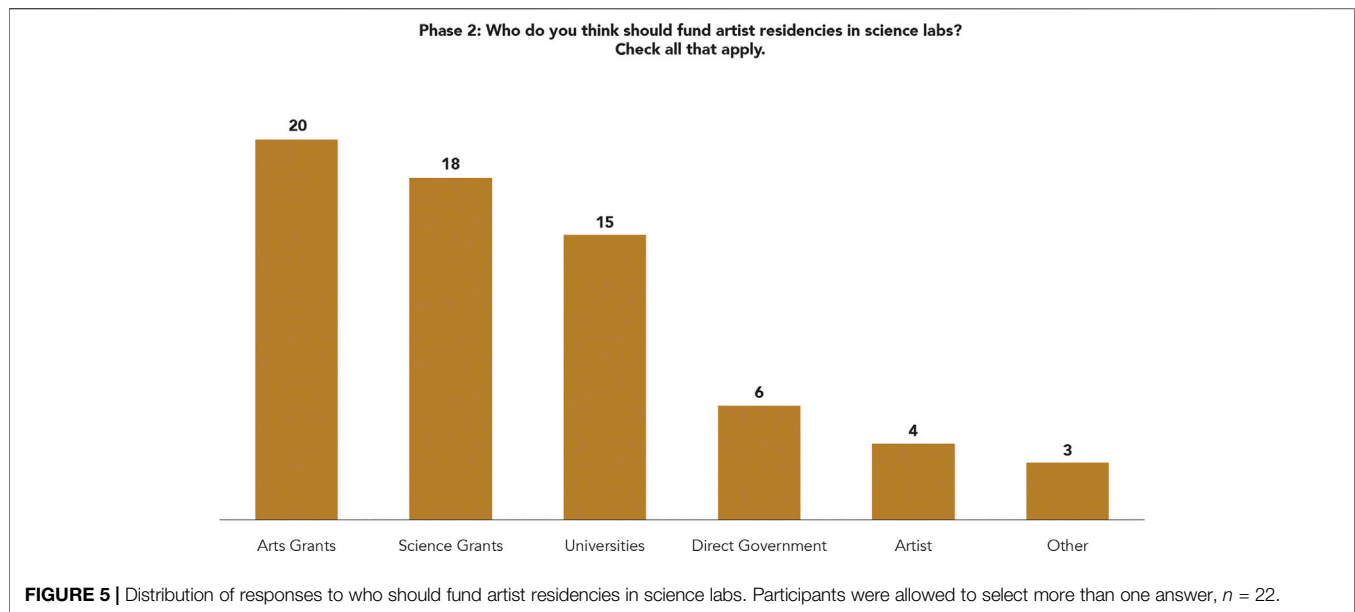


TABLE 8 | Summary of survey responses, $n = 55$.

Question	Artist	Scientist	Other		
Which of the following best describes you?	14	17	24		
Question	20–29	30–39	40–49	Over 50	
What is your age range?	17	22	11	5	
Question	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
I enjoyed this online exhibit	—	—	9	29	17
I learned something new from this online exhibit	1	4	16	16	18
This was an effective and engaging way of bringing together art and science	—	3	5	27	20
I would recommend this online exhibit to a friend	1	5	10	18	21
I had technical difficulties during my online exhibit experience	37	15	2	1	—
Question	Artwork	Science Communication Product	Both	Other	
Between the Sand is?	2	5	45	3	

public. Fourteen comments were strictly about the visual aesthetic or entertaining interaction with the online exhibition, while only four comments shared sentiments of uncertainty about the purpose of the exhibit. See **Table 6** for examples of responses for each theme.

A total of 50 participants (out of 55) provided comments on what could have improved their online experience. Most comments (24) fell under the theme of technical components which could improve the overall user experience, such as changing specific controls, including audio or additional features. Fourteen comments centered around providing more context and/or a bigger picture as to why this was important

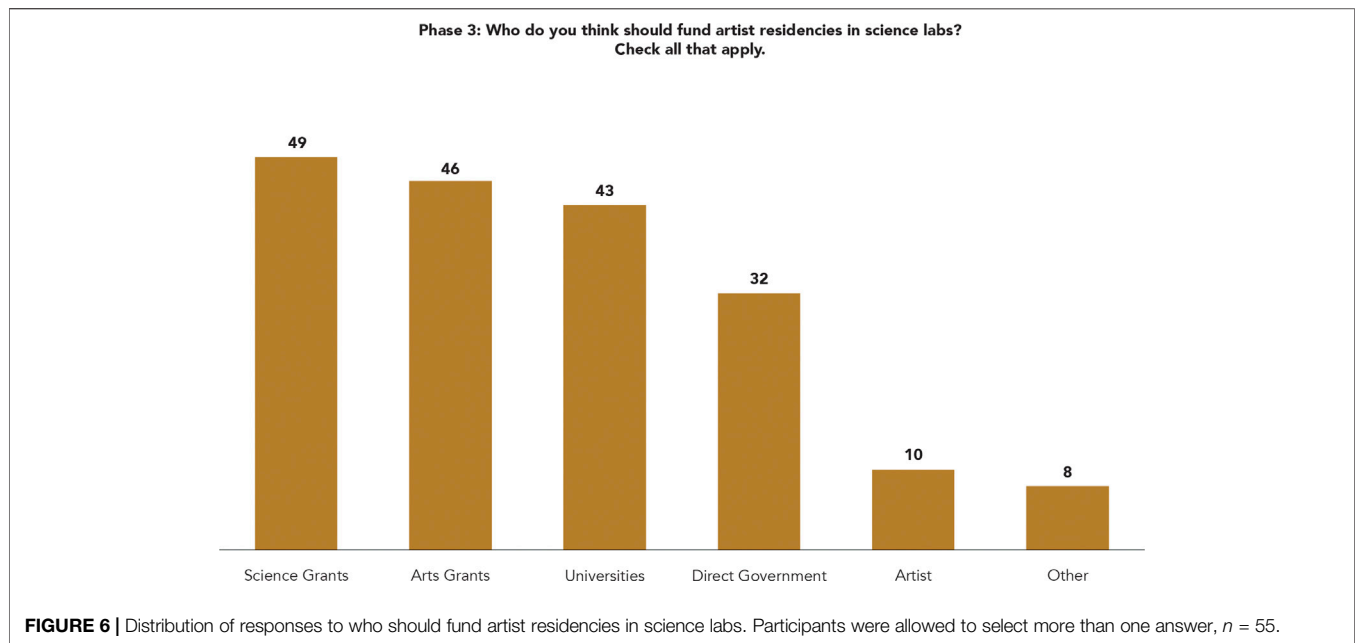
research and how it could be applied. Finally, four comments were placed into the theme of questions and/or uncertainty of the purpose of the artwork. See **Table 7** for examples of responses for each theme.

DISCUSSION

Phase 1—Impact and Perceptions

Artist Perspective

For the artist, there was a newfound appreciation for the structure of research from the planning and precision of experiments, to the



sheer knowledge and dedication of the research group. This realization motivated the artist to do more readings, to better understand the technical terms, and make more informed questions in order to find his own angle for the artwork. The short time frame of the residency also encouraged the artist to step out of their comfort zone to seize opportunities and ask questions. Similar sentiments were also reported by artists who participated in the Wellcome Trust's Sciart Programme. Initially, they felt intimidated or in awe of stepping into the realms of science, but then gradually gained confidence to affirm their identity in an unfamiliar domain (Glinkowski and Bamford, 2019).

In the pre-residency concept mapping, the artist identified the importance of new perspective, and how an artist could potentially contribute to scientific research. This theme seemed to influence the artist's approach early on in the residency, when he was trying to find what his contribution would be. The artist was certainly not alone in this thinking, as the notion of whether art can link to improvements in scientific process and outcomes has also been questioned by others (Stevens et al., 2019). There have been moments when this has occurred, for example, when a phenomenon in Antarctica photographed by Schulthess (1960) prompted further scientific analysis (Tricker, 1972). However, this may not always occur, and artists may find themselves redefining what that contribution means to them. During this residency, the artist quickly realized that his contribution would not be a "eureka" moment for the research group, but rather his own unique contribution based on what he experienced.

Scientist and Research Group Perspective

The scientist and his research group certainly saw and experienced the impacts of having the artist in the lab. Similar to the artist, the theme of new perspective was mentioned in the scientist's pre-residency concept map and was manifested during

the residency in many forms. Lab members described how their repetitive tasks suddenly had new meaning, as they thought about how to explain what they were doing and why. With encouragement from the artist, graduate students broke away from the scientific methodology they knew, to play and look at their experiment in a different way. Such sentiments around new perspectives were also reported by scientists who participated in the Sciart Programme (Glinkowski and Bamford, 2019).

While the scientist shared his enthusiasm about the impact of the artist on his research group, his skepticism in his own ability to communicate still remained post-residency. The scientist credited the artist for keeping up with the technical jargon he used but questioned whether he could actually communicate his work to someone without the artist's science background. Interestingly, Glinkowski and Bamford (2019) reported that 66% of artists who participated in the Sciart Programme had some kind of scientific background prior to the project. Thus, it is possible that artists with a closely aligned background could increase the chances of successful interdisciplinary experiences or collaborations. Otherwise, facilitation and a longer residency period should be considered to ensure an effective artist and scientist interaction.

Despite mostly positive comments, one graduate student voiced the uncertainty of whether this science-art approach would be widely accepted by the scientific community, particularly experts in his field who were older and more traditional. Previous attempts to gauge the role of art in science communication among scientists have shown that while 55% agreed that science-inspired art made them reflect on alternative ways of communicating science, a majority (72%) would not consider or were not certain about using art in conjunction with their scientific work (Curtis et al., 2012). One reason that could explain the hesitation to integrate the arts may go back to the nature of the scientific profession. As the scientist mentioned in his pre-residency interview, for young researchers, the focus is on advancing their research discipline

which will in turn advance their career. This notion and the lack of incentives to do outreach among scientists is also noted by Schnugg (2019) and Glinkowski and Bamford (2019). Perhaps this observation is a good prompt to question and/or challenge the current structures in place, so that there is more support and opportunities for scientists to work with those outside their disciplines.

Value of Interaction

Despite the 2-week duration of this residency, it still allowed for many learning opportunities and valuable insights for the artist, scientist and research group. Themes such as new perspectives and benefits to society overlapped in the concept maps for both the scientist and the artist, pre- and post-residency. This consistency suggests that these particular ideas and expectations continue to be important components of the “value of an artist in the science community”, perhaps because they were observed during the residency. It may also suggest that shared values and respect for the other discipline are integral for a meaningful and successful residency experience.

While there were many themes which were shared between the artist, scientist and lab members, there were also some which were only identified by one or the other. For instance, the artist likely emphasized the importance of asking questions and validating work since this was something he was actively doing in order to achieve his goal of creating an artwork that accurately reflected the research being conducted. On the other hand, the scientist and lab members highlighted the importance of gaining new skills from the artist, as this could be helpful in their research careers. Observing more conversations and discussions was also likely easier for the scientist to notice as this was an expectation he had before the residency. Since both parties had different priorities and expectations to begin with, it is likely that some benefits and observations would also be different.

Overall, the residency left the artist feeling confident and excited to pursue the next step in his challenge to create and present the research-inspired artwork. It also provided him with a learning experience which could inform his future collaborations and art practice. For the scientist, he anticipated that these new ideas and perspectives gained from the residency would percolate through conversations beyond their immediate peer group, and eventually to the public sphere. He also highly recommended other researchers to take on such an opportunity, as the benefits for the research group were well worth it.

Residency Model

Artist residencies may range from 1 week to 1 year in duration and function differently. The structure of this residency did not require the artist to have a finished art piece at the end of the 2 weeks. Rather, the 2-week time frame provided space for learning and ideation to inform the artwork. The artist was then provided several months to complete the artwork on their own with some correspondence with the research team if needed.

It is important to note that the structure of this residency was not an artist-scientist collaboration where the two worked together to create a piece, as seen in the Sciart Programme (Glinkowski and Bamford, 2019), SciArt Center Bridge Residency or in Halpern’s (2011) work on observing the collaborative process between artist and scientist. Instead, the

artist was integrated into the scientific environment as a fellow lab member, to draw inspiration and knowledge for his artwork.

Interestingly, Glinkowski and Bamford (2019) evaluation interviews revealed that the Sciart Programme seemed to favour the artists, in that they had the most to benefit from the opportunity. Given the nature of a scientist’s profession, it may be understandable why they were not as heavily involved. However, ATS’s residency approach may help to overcome some of these barriers by providing flexibility of involvement for the scientist as to not take away time from their research. In addition, the artist is given an opportunity to explore and develop relationships with other lab members, which could have a larger, collective impact compared to a one-on-one collaboration.

Phases 2 and 3—Local/Online Events Exhibition Logistics and Evaluation

Since the in-person event was held in a community environment (not at the university), it allowed for a broader audience reach, outside the university establishment. On the other hand, the online exhibition provided a larger and more accessible public platform for the artwork. Since it was optimized for most web browsers and rural internet connections, most participants (94.5%) did not report any technical issues with the exhibition interaction. Internet and browser accessibility verification is an important consideration when creating online exhibition experiences.

Similar to other science-art outreach initiatives (Drumm et al., 2015; Rosin et al., 2019), the *Between the Sand* local event embedded evaluation into the program to encourage participation and to ensure that participants understood the context of the questions they were asked. Throughout the event, participants were reminded to take part in the survey and volunteers circulated the room to provide survey materials, making it easily accessible. Similarly, for the online exhibition, the survey was incorporated into the menu and participants were able to access this link directly in contrast to the customary feedback popups that were triggered upon leaving the webpage.

Attendee Demographics

The local event had attendees from varying backgrounds with artists and scientists comprising a majority. This suggests that integration of art and science is of interest to both groups. This was also observed across participants viewing the work online. The age range of participants for the online exhibition revealed that age groups (20–39 years of age) who are generally more comfortable with technology made up the majority of participants, while only a small portion (9%) were over the age of fifty. This lower senior participation rate may be attributed to lack of access to technology or skills to access online experiences. A general lack of seniors online may also have contributed to this lowered participation as the online exhibition was shared digitally via social media. Finally, senior populations may be less interested in digital art forms compared to traditional ones (Drumm et al., 2015).

Learning Opportunities

Art provides an avenue of learning similar to the museum and science centre experiences. Although *Between the Sand* cannot compare to a full museum or science centre experience, both the

in-person event and online exhibition provided an opportunity for free-choice learning that is guided by the learner's needs and interests (Dierking and Falk, 2003).

The local event fostered some elements of a discovery learning environment (Hein, 1998) which had a range of active learning modes, including: 1) The interactive artwork that attendees could physically manipulate; 2) Videos and actual apparatuses from the lab; 3) A panel discussion with a Q&A and 4) Opportunities to connect and discuss with the artist, scientist, and lab members directly about their work. As a result, over three-quarters (77.3%) of the participants agreed they learned something new from the artwork and provided a wide range of answers of what they learned from the experience. These responses stemmed from learning about a novel art medium (creative coding) to learning about specific details from the scientific research and process. For many, attending this local event affirmed the value of bringing science and art together. In addition, participants who watched the panel discussion agreed that it contributed to the understanding of the work. This suggests that incorporating artist/scientist talks along with the artwork can enrich the public learning experience.

However, this local event did miss some components of a discovery learning setting, which many participants actually noted in their feedback. The event lacked didactic components such as labels, panels or handouts that provided further context, prompts or questions to encourage the visitors to find out more about the topic (Hein, 1998). Including more didactic components would have also allowed participants to get a quicker understanding of the topic upon entry and help provide context during the time they were waiting to interact with the artwork, lab equipment, artist, scientist or lab members.

The online exhibition fostered more elements of constructivist learning, as there was no "right" way to experience the exhibition, allowing for experimentation and play (Hein, 1998). Users were able to click in multiple areas and adjust different settings to see how they could change the flow pattern of contamination. However, there were didactic components in the menu which provided more context about the artwork and scientific research. While this digital version certainly did not have the same in-person learning opportunities as the local event, it did provide more accessibility (anybody with the link could interact with the exhibition) as well as time to play and explore (unlike the local event which had a clear start and end time).

For the online exhibition, 61.8% of survey participants agreed that they learned something new. Similar to the local event, participants provided a range of responses on what they learned. Some were fixated on the aesthetic components of the exhibition, others learned about the importance of the research which the artwork was inspired by, and many were intrigued by this cross-disciplinary approach to engaging the public. There were also a few participants who were left with more questions and wanted to learn more about the artwork or research. Such diverse responses are almost expected from constructivist learning, since providing the participant an opportunity to construct personal knowledge means there is a possibility for them to have a different interpretation from what the designers (or in this case, the artist) intended (Hein, 1998).

Interestingly, the feedback for the online exhibition would strengthen this constructivist learning experience. Many

participants suggested more modes of learning through added features that would allow for even more play and experimentation, such as changing the size of the sand grains or incorporating audio. Others wanted different ways to connect to the research and how this could be applied in the real world. All in all, participants enjoyed this approach to learning, which provides promising prospects for future digital learning experiences integrating art and science.

Science-Art Perceptions

Communication to promote both local and online exhibitions positioned *Between the Sand* as a research-inspired artwork, yet the majority of participants (79.2%) from both exhibitions identified it as both an artwork and a science communication product. This finding suggests that science-based art may have the potential to communicate science, even when it is not promoted as a science communication effort.

Most participants (88.3%) of both the local and online exhibitions thought the initiatives were an effective and engaging way to bring art and science together. Both scientists and artists comprised the participant group which reveals that both groups may be interested in interdisciplinary projects combining art and science. Furthermore, 95.5% of survey participants from the local event strongly agreed that interaction between artists and scientists can have societal benefits. This finding supports the recent trend in increased initiatives centred around art and science collaborations (Feder, 2021; Gewin, 2021). It should be noted however, that some artists are hesitant about having their art serve as a science communication product (Sleigh and Craske, 2017).

Artist Residencies in Science Labs

Survey participants at the local event were asked why they thought artist residencies in science labs were important and were given four possible answers (Figure 4). Most participants thought that artist residencies in science labs can be beneficial to both the participating artist and scientist by providing inspiration and new ideas. This result aligns with the findings for Phase 1, where the sub-themes of new perspective and inspiration emerged for both artist and scientist before the residency (Table 1). Similarly, a survey by Sleigh and Craske (2017) revealed that artists collaborating with scientists allowed for the development of valuable relationships and enriched their art practice. Participants also acknowledged that these residencies are important, because the artist can provide a new perspective on scientific research. New ideas are critical for advancing scientific discovery, thus inviting a new perspective into the research group may help unveil pathways to advance and/or communicate the research. The Phase 1 findings also support this notion, as the artist, scientist, and lab members shared this view after the residency (Table 3).

Survey participants of both local and online exhibitions were asked to select all listed entities that should fund artist residencies in science labs. Science grants (67/77 responses) and arts grants (66/77 responses) were the most selected funders followed by universities (58/77 responses) and direct government funding (38/77 responses). These responses reveal that public perception of funding is not skewed to either discipline and instead seems to call upon both

TABLE 9 | Summary of recommendations for future residencies.**Art the science residency recommendations**

Funding	Should cover the following costs: <ul style="list-style-type: none"> • Artist's living costs • Artist fee • Scientific materials • Artwork production materials • Exhibition support
Scientist experience	<ul style="list-style-type: none"> • Departmental encouragement and support • Engaged research group • Involvement in artist selection process • Facilitation by residency provider
Artist experience	<ul style="list-style-type: none"> • Adequate residency duration • Full-time basis • Integration into the research group as a valued member • All training required for lab autonomy • Creative control over artwork direction • Equal access to reagents and equipment when possible • Facilitation to support the artist and scientist when required
Public exhibition	<p>Local:</p> <ul style="list-style-type: none"> • Host exhibition events outside of research institutions • Invest time into directed exhibition promotion initiatives to engage diverse audiences in the local community <p>Online:</p> <ul style="list-style-type: none"> • Include UI/UX considerations during the design process • Create inclusive online experiences
Evaluation	<ul style="list-style-type: none"> • Design and plan program evaluation initiatives well ahead of the residency and inform hosting research facility and artist • Embed evaluation initiatives as part of the event experience not as an afterthought

science and arts grants to fund such interdisciplinary initiatives. In Europe, government grants already support science-art projects (e.g., STARTS initiative), while other countries like Canada (where this residency took place) are currently lacking formal science-art funding opportunities. Survey responses also revealed that universities could be appropriate funders for artist residencies in science labs. This funding would likely come from grants that principal investigators typically apply for. However, while there are benefits of incorporating budgets for science-art initiatives in scientific grant applications, the artist's experience may become outcome-driven and constrained to meet the expectations of the research objectives (Sleigh and Craske, 2017).

Recommendations

Recommendations from the findings of this paper as they relate to facilitating a comprehensive science-art residency program are documented in **Table 9**.

Establishing funding for artist residencies in science labs is critical for artists and scientists interested in collaborations. While traditional models for artist residency funding are already established, cost for scientific equipment and supplies need to be considered when budgeting for a science-artist residency. In addition, the scientist should seek support from their department in order to engage a broader research community with the artist in residence. Organizations providing the residency should ensure the scientist is part of

the artist selection process early on, when potential themes and other residency application criteria are established. Creating such criteria with the scientist will help outline the expected outcomes and vision for the residency. It is important to establish the incoming artist as a member of the research group to ensure a truly immersive residency experience. In addition, all parties involved should acknowledge that science communication may not be one of the artist's goals during the residency. The artist may consider creative input from the scientist, but should retain the ultimate creative control for the direction of their work.

Defining an adequate residency duration for Phase 1 of an immersive residency is critical for the success of the other two phases. The most feasible recommendation would include a 2–3 weeks immersive component with compensated self directed time for the artist to complete their artwork for the subsequent exhibitions. As the artist noted in their post-residency interview, 2 weeks would not have been enough time to complete the artwork and therefore, a longer duration would be ideal if the artist is expected to have a finished art piece at the end of the residency. On the other hand, the scientist fully supported the 2-week duration of the residency, with a possibility of extending another week only to accommodate unforeseen circumstances (e.g., no lab experiments being conducted).

Lengthening or increasing the frequency of events in the future could contribute to an increase of attendees. However, the time of both the artist, scientist/research team should be accounted for in the planning of the events to ensure it is feasible. Otherwise, evaluators

must be adaptable and consider alternative methods of engagement and data collection (e.g., digital/online events). It may also be helpful to connect with the artists and scientists after Phase 2 or Phase 3 of the residency to collect their thoughts about final artwork and their experience with public engagement.

Limitations

Due to the small sample size and the nature of this science-art residency, these findings may not apply to broader science-art experiences or collaborations. Respondents from the Phase 2 survey were limited to the small city of Kingston, Ontario within a short timeframe (1 day, 3 h event during inclement weather), which likely contributed to the small number of attendees.

In addition, surveys were not conducted before the in-person or online exhibition, as these questions may have discouraged attendees and/or affected their perceptions before experiencing the actual event and therefore, impact their final impressions. Although the Chronbach's alpha for the Phase 2 survey was low, it should be noted that only three statements were included in this test, along with a smaller sample due to inclusion of a statement with non-applicable (null) as one of the answers. A reduced alpha is commonly seen in tests where there are fewer items (Nunnally and Bernstein, 1994).

While it would have been interesting for the scientist and/or research team members to document their experience in a daily diary, this was not practical given their busy schedules and the immense effort that was already put into the logistics of having an artist in their laboratory in the first place. Unlike other science-art residencies and programs (e.g., Wellcome Trust Sciart Programme) where scientists and artists are both responsible for creating the artwork, this residency immerses the artist into a scientific research environment, allowing them to learn and collect information for their research-inspired artwork. This approach also allows the research team to engage with the artist without compromising their research priorities. While more documentation is ideal, it is important to draw boundaries and understand when evaluation can impede the experience for participants.

CONCLUSION

Through the use of qualitative and quantitative methods, including interviews, concept mapping, video diaries, and surveys, these findings revealed that a comprehensive Science-Artist Residency program facilitated by Art the Science had a valuable impact on everyone involved: the artist, the research group, and the public. Providing opportunities where disciplines can work together also enables a creative means to connect with the general public through story and process to ignite meaningful discussion, knowledge sharing, and active learning.

AUTHOR'S NOTE

The scientist and artist were introduced by their real names because *Between the Sand* is a public artwork which includes complete documentation of the residency and those involved online as well as articles published in media outlets. Because of the public nature of the residency, it is not possible to guarantee anonymity to the scientist and artist. They were both made aware of this from the beginning and did not object.

DATA AVAILABILITY STATEMENT

Data supporting the conclusion of this article will be made available by the authors upon request in accordance with the Research Ethics Board of Laurentian University's Research Office.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Research Ethics Board, Laurentian University Research Office. The participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

JK—writing, editing, data collection, data analysis, data visualization CL—writing, editing, data collection, data analysis, references CB—editing, ethics.

ACKNOWLEDGMENTS

Art the Science's pilot science artist residency took place on traditional Anishinaabe and Haudenosaunee territory. We would like to extend our immense gratitude to Kevin Mumford, Cole Van De Ven and the entire research group at Queen's University. We would also like to thank residency participant and artist Owen Fernley. Finally, the residency would not be possible without the dedicated work of many Art the Science volunteers including Alexandra Pedersen, Liam Rémillard, Diana Gore, Celia Du, Alice Fleerackers, Dorina Simeonov, McKenzie Prillaman and the rest of the team.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/feduc.2021.690489/full#supplementary-material>

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