Broader Impact: Volcanic Ash Summative Evaluation Report

Prepared for

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INTRODUCTION

Project Background

This project promoted public awareness of the *Collaborative Research: Measurement of Particle Aggregation in Laboratory-scale Flows for Improved Models of Volcanic Ash Fallout and Entrainment"* ("*Volcanic Ash*") project, led by Dr. Stephen A. Solovitz (Washington State University, Vancouver), Dr. Raul B. Cal (Portland State University), Dr. John K. Eaton (Stanford University), Dr. Larry G. Mastin (U.S. Geological Survey, Cascade Volcanoes Observatory), and Dr. Alexa R. Van Eaton (U.S. Geological Survey, Cascade Volcanoes Observatory). The goal of the *Volcanic Ash* project was to engage public audiences and develop an improved understanding and modeling of volcanic ash aggregation and dispersal, which will be used to aid in forecasting volcanic hazards.

This project was modeled after OMSI's *ResearchLink* (DRL-1241331) initiative, which features a set of dynamic programs and exhibits where active, local research is featured. The scientists participated in the museum's Science Communication Fellowship Program: a "short course," of science communication professional development workshops facilitated by professional museum educators and informal learning experts. The workshop content is based on modules from the NSF-funded *Portal to the Public* project (DRL-0639021). These workshops helped the research team develop an understanding of how to effectively communicate with diverse public audiences and develop a hands-on activity to be facilitated at the museum by the researcher scientists. The hands-on activity serves a dual function: highlighting unique elements of the research, and putting a human face on the current science content. The activity was designed to promote participant use of critical thinking skills similar to those used by the active researchers.

The target audience for the demonstration is family groups visiting the museum, which was chosen for two reasons. First, awareness and engagement with STEM subjects has been demonstrated to increase the likelihood of children entering the STEM workforce (Bell, Lewenstein, Shouse, & Feder, 2009). Second, research has demonstrated that science learned in a social environment offers greater chance for ongoing inquiry (Schweingruber & Fenichel, 2010). The target impacts of the outreach are:

1. Public audience participants will be engaged and interested in the volcanic plume research being presented.
2. Public audience participants will be aware of and have increased knowledge related to the research being presented.

As described in additional detail below, the impacts of the COVID-19 pandemic caused a shift in evaluation activities, which were originally planned to include observations and surveys of visitors engaging with the demonstration. However, as data were unable to be collected in 2020, the scope of evaluation activities were adjusted to focus on the perceptions of the demonstration facilitators as opposed to the experiences of museum visitors engaging with the demonstration.

Events & Audiences

The demonstration was presented at the museum at four *Meet a Scientist* events in addition to a *Pride at the Museum* event. Prior to March 2020, *Meet a Scientist* was a program held on the second and fourth Saturdays of each month featuring local scientists affiliated with OMSI's Science Communication Fellowship who would present and share their research and knowledge with museum visitors through hands-on activities, demonstrations, and conversations. The *Volcanic Ash* demonstration was presented to general admission visitors during *Meet a Scientist* for about three hours at each event (from 1:00PM to 4:00PM Pacific time). Based on log counts of visitor traffic throughout the museum collected by OMSI staff and volunteers, the estimated total number of visitors that interacted with the demonstration at each event date were:

- January 12, 2019 - 75 visitors
- January 26, 2019 - 123 visitors
- May 11, 2019 - 39 visitors
- May 25, 2019 - 81 visitors

Pride at the Museum was a special ticketed event held on June 14, 2019 from 6:00PM to 10:00PM (PDT) that welcomed visitors of all ages to engage with Pride-inspired science demos, guest scientists, aerial dancers, drag performances, music, and complimentary admission to the featured exhibit. The demonstration was presented to attendees throughout the duration of the event.

Facilitators

Facilitated demonstrations afford opportunities for hands-on interaction with museum visitors. Facilitators for this project included scientists and members of their research team from WSUV that participated in OMSI's Science Communication Fellowship. The two primary facilitators were both graduate students at WSUV completing degrees that involved research related to *Volcanic Ash* content and concepts. The project PI was closely involved in the demonstration development process and was also present to observe some of the facilitated demonstrations at the museum. Together, these three project personnel served both as the primary facilitators of the *Volcanic Ash* demonstration and as the participants in the summative evaluation discussed herein.

Impacts of the COVID-19 Pandemic

In mid-2020, WSUV researchers who were part of OMSI's Science Communication Fellowship program planned to present their demonstrations at OMSI's *Meet a Scientist* events where evaluators would assess their effectiveness through direct engagement with public audience members. The evaluation study design included observations, interviews, and a short survey to be distributed to general audiences that engaged with the demonstration. Through these data collection methods, the planned study explored the extent to which the demonstration was engaging, educational, and meaningful for public audiences, as well as assessing the additional value that interacting directly with a local scientist provided.

In March of 2020, OMSI had to close its doors due to the COVID-19 pandemic, effectively halting the possibility of conducting *Meet a Scientist* events and, thus, the evaluation of the WSUV Volcanoes project as initially envisioned. Although the museum re-opened in 2021, the WSUV researchers were unavailable to present their demonstrations due to public hesitancy with hands-on engagement that led to the delayed reinstatement of *Meet a Scientist* events, so a new evaluation strategy and scope were developed.

The adjusted evaluation activities collected data from the demonstration facilitators rather than the general public to explore facilitator perceptions of the extent to which and the ways in which the demonstration was engaging, educational, and meaningful, as well as the impact presenters perceived they had by interacting with the public in person. The following sections of this report outline methods and findings associated with this adjusted study design.

METHODS

Interview methods were utilized in this study to collect facilitators' perceptions of the impacts of the demonstration for both visitors and themselves.

Participants & Data Collection

Interviews were conducted remotely in January 2022 with three members of the WSUV research team including the project PI and two graduate student researchers, all three of whom previously participated in OMSI's Science Communication Fellowship where they collaborated to develop the demonstration. Two interviews were conducted via Zoom while the third was conducted via email correspondence due to scheduling conflicts and constraints; the latter interview relied upon written responses to interview questions that were shared with participants as part of the interview protocol (Appendix A). The interviews and corresponding

data analysis were conducted by a member of OMSI's Engagement Research and Advancement team assigned to lead this summative evaluation study; this evaluator possesses seven years of training and experience in qualitative research and evaluation methods, with a particular focus on the context of informal STEM engagement. Interviews conducted via Zoom were recorded and transcribed, and the interviewer took detailed notes during both interviews. These transcripts and notes were then analyzed qualitatively along with the written responses of the third participant.

Analysis

Interview data for each participant were entered into Google Sheets and inductively analyzed to determine commonly occurring themes across responses as well as identify unique anecdotal evidence beyond the identified themes. Themes and anecdotes were organized and described, and representative example quotes were selected and highlighted in this report.

Limitations

Due to the impacts of the COVID-19 pandemic on the overall evaluation activities that prevented data collection with museum visitors that engaged with the demonstration, the data collected and presented were limited to the perceptions and memories of only three participants. Additionally, the interviews were conducted nearly two years after the demonstration facilitations took place, which likely impacted the accuracy of participant recollections. These limitations were mitigated somewhat by the fact that the three study participants represented the project personnel who were most deeply involved in demonstration development and presentation. Finally, the interviews were not conducted consistently for all three participants, as two participated remotely via Zoom while the third provided written responses to the questions provided in the interview protocol due to scheduling conflicts and constraints.

FINDINGS

To evaluate visitor engagement and overall impacts of the demonstration, qualitative data based on interview questions provided to the scientists that developed and facilitated the demonstration activities were analyzed to identify common themes. Findings are presented based on four categories that were identified as being relevant to the overall project goals:

- Visitor Engagement
- Visitor Learning
- Impacts on Visitors
- Impacts on Scientists

Visitor Engagement

Participants were asked to comment on what they thought initially drew visitors to engage with the demonstration based on their experiences both facilitating and observing demonstration activities. All three participants noted that the presence and use of athletic and toy balls of various sizes and colors, such as ping pong balls, baseballs, cloth balls, and others, was very appealing to visitors, especially children. Additionally, the element of moving air generated by the use of a fan created sounds and motions that appealed to visitors' other senses, piquing their attention and curiosity about the demonstration and its activities. Visitors' actions of dropping balls onto a ramp, which were impacted by the fan, also added an element of disorder as the balls would exit the ramp and/or the demonstration area at times, which then attracted nearby visitors who noticed the balls outside of the demonstration space.

Beyond initial engagement, participants were asked what they believed to be the most interesting or exciting aspects of the demonstration for those visitors that opted to participate. Two of the three participants commented on the action that participants would take by dropping one or multiple balls onto the ramp to observe how and where they would eventually settle based on different factors (such as size, weight, material, and the influence of the fan). One noted that they felt these actions were more attractive to younger visitors, mostly children, compared to adult visitors. They commented that adult visitors seemed more interested in learning about and discussing facts associated with volcanic ash, and especially sharing stories or memories related to the volcanic activities of Mount St. Helens, an active stratovolcano located in nearby Skamania County, Washington, which is a little over 50 miles from where the demonstrations were held at OMSI in Portland, Oregon. Each of the three participants also mentioned that visitors seemed interested in the overall outcome of the demonstration. One participant mentioned that the consistency of the results was notable for many visitors and

another participant recalled a number of visitors comparing the outcome to predictions they had made during their initial engagement with the demonstration.

"I would ask kids if they thought volcanoes were cool, and the ease of interaction with my demonstration. There was a basket of balls of varying weight and color, and a funnel they would drop them in."

"We made sure to keep everything colorful…there was also a fan going the whole time, which people seemed to notice that–the movement of it. I think especially for kids…it was very hands-on and kind of like something they knew."

"The two things I always saw [engage visitors] was a lot of sports balls, so people got their eyes like 'Ah, I know what these things are; I'm familiar with that.' And the second thing that tended to draw people to it is it's things flying across the room…especially with younger attendees that always draws attention so it just looked fun to play around with, at least initially."

Visitor Learning

Regarding the perceptions of visitor learning that occurred via engagement with the demonstration, participants recalled that generally visitors were able to make connections between the demonstration activities and concepts related to volcanic eruptions and ash fallout. When asked about what they believed to be the key knowledge obtained as a result of participating in the demonstration, all three participants mentioned that visitors learned about the different paths and impacts on volcanic fallout during volcanic eruptions. They explained that many visitors learned that fallout includes more than smoke and ash, including pebbles, boulders, and different kinds of ash, and their paths differ during eruptions based on a variety of factors such as size, shape, density or weight, wind, and turbulence. One participant also noted that some adult visitors made connections between the paths and impacts of ash fallout as represented in the demonstration and their memories of experiences with ash fallout from activity of Mount St. Helens.

In terms of demonstration content and concepts that were challenging or confusing for visitors, participants had varying perceptions but generally agreed that higher-level conceptual knowledge may have been overlooked or misunderstood. One participant expressed that based on their observations and interactions with visitors, they did not believe that visitors were able to clearly make connections between the demonstration and the volcanic plume and ash research that served as the foundational content and concepts of the demonstration, which all three participants were actively involved in. They believed that some of the conceptual elements

related to the role and impacts of inertia on volcanic fallout were likely not grasped by visitors. Another participant believed that visitors that approached the demonstration while it was in progress rather than at its initial "start" state as designed may have been confused and/or would not remain engaged with the demonstration as they had missed the beginning, which included introductory and background information surrounding the demonstration and associated scientific concepts. The third participant noted adult visitors' hesitation or general lack of engagement compared to children. They also mentioned that some children would be primarily interested in playing with the balls rather than engaging with the connections to scientific concepts, and their actions and behaviors of play could be distracting for other visitors that were interested in learning about the demonstration and the science behind it.

"I think they definitely learned that volcanic fallout isn't just smoke or ash–I think a lot of people were surprised when we talked about that…there's giant boulders that come out, there's also pebbles and there's different types of ash, too. Ash can be a lot of different things, and it can be this tiny little thing and it can also be big flakes that go different distances."

"Volcanoes explode with such incredible force that large rocks and ash are sent miles high and when it's windy, that ash can travel hundreds of miles. That was the main takeaway that I would leave with them so hopefully that's what they learned."

"[The demonstration] had a lot of adults telling you stories about their experience with it…like 'Hey, i had this experience with ash or I had this experience with like smoke or something,' and I could be like 'Oh yeah, well that connects to this part of the demo' and I feel like it kind of brought it to them on a personal level."

"I think the most confusing thing is kind of closing the loop on what to actually do in the demo to what it actually means for us when we're in the lab. The whole purpose of inertia for us is it has a big effect on the way particles move around in a plume and how they stick together…I'm not sure that necessarily got connected [for visitors] when I watched [the demonstration]."

Impacts on Visitors

Participants were asked to comment on what they perceived to be the value or enrichment of their presence and facilitation as professional scientists for visitors that engaged with the demonstration. All three participants offered remarks aligned with the notion that their presence and role as a scientist helped to mediate the scientific interests and learning of visitors with the research and concepts around which the demonstration was designed and focused.

Two participants, who were both graduate students at the time of facilitating the demonstration, especially believed that their participation contributed to humanizing science and scientists for visitors. They each made comments about how their presence could inspire young people to be scientists, and deepening their connections with science and STEM more broadly.

One participant expressed that she felt she was serving as a role model, especially for girls and young women that may be interested in STEM. She felt that her interactions and connections with girls and young women in the context of the demonstration could be very impactful for them, and opportunities like this for girls and young women to engage with women scientists can help work towards reducing the gender gap in STEM.

"To actually get why it's meaningful…I think that if you don't have a scientist there to talk about it or even have some kind of display there to explain 'this is what you're seeing, or some path of this is what you're seeing,' I think it could almost get lost in just 'let's play around with what's going on in the lab.' So I think this is a particular case where having the scientists there made a huge difference.

"I think on a personal level it was very cool to be interacting with young women…the gender gap in STEM is really frustrating and really ridiculous…[it is] pretty cool for me to be able to interact with girls and young women in general, and just kind of be a sort of role model."

"Having someone with firsthand experience in the field brings the expert right to the demo. By including our perspective, it adds a level of understanding and clarity that benefits the visitors…I think it's cool that kids get a chance to interact with graduate students and see their research. It gives a direct look at what it means to do research and if one more kid thinks science is cool or wants to be a scientist, it's worth it."

Impacts on Scientists

While most of the questions posed to participants focused on their perceptions of visitors' experiences and engagement, they were also asked to offer reflections on meaningful memories or overall impacts for them as scientists communicating with public audiences. Overall, two of the three participants mentioned the value and meaning in bridging the gap between public audiences and scientific research. They expanded that as scientists facilitating the demonstration with general public audiences, which were the museum visitors, they were able to leverage science communication skills to get people interested in and excited about science in a fun and experiential way.

One of these two participants also noted that they found the opportunity to interact with people from a diversity of backgrounds and levels of understanding (in terms of scientific knowledge) to be especially valuable for them as a scientist and science communicator. The other participant reflected on how fun it can be to "break the rules," and how this can be somewhat analogous to science and nature. They shared that many visitors enjoyed the opportunity to dump many different balls at the same time as a bit of a "finale" to the demonstration, and this action of doing something that may seem like you should not do it is not unlike volcanic activities and eruptions. This seemed to add even more fun (and connections to science) to the overall demonstration and the experiences for both visitors and the scientists alike.

> "There's just a really huge gap between the actual research being done and being able to present it to the public and how science is perceived by the public. Being able to practice [with the public] for hours at a time with all different sorts of people from all different backgrounds and kind of gauging that level of both interest and background knowledge…was really really valuable I think."

> "I think the most meaningful thing for me is always seeing people get excited about doing some kind of projects like this or some kind of demonstration…especially when you started dumping the whole bucket of all the balls at the very end was always like the eyes lit up, especially with the younger attendees, They just thought it was really cool and really fun…they always like it when you do something just a little bit wrong, or knowing it's wrong, because it's a fun thing to do–the thing that doesn't seem like what you're supposed to do, and yet the remarkable thing is, it *is* what you're supposed to do, and it's like that in any volcanic eruption–it's also a whole mess of stuff coming out of there."

Summary & Conclusions

The target impacts of the outreach for this project included the engagement, interest, awareness, and increased knowledge of public audience participants related to the research associated with the *Volcanic Ash* demonstration. While the original evaluation plan relied upon data collection from visitors that engaged with the demonstration via observations, interviews, and a short survey during demonstrations facilitated in 2020, the impacts of the COVID-19 pandemic forced adjustments to the plan. An updated evaluation plan was devised and implemented that focused on the facilitators of the demonstration rather than the general public to gather insights on how the facilitators perceived the demonstration to be engaging, educational, and meaningful for visitors, as well as their perceptions and reflections of their roles as scientists and the impacts their presence, communication, and facilitation had on public audiences.

Based on interviews with the researchers who served as the demonstration facilitators, as well as the project PI who was closely involved in the development of the demonstration and observed its delivery in the museum, findings were organized and presented based in four categories relevant to the project's outreach goals including *Visitor Engagement, Visitor Learning, Impacts on Visitors*, and *Impacts on Scientists*. Regarding *Visitor Engagement*, all three interviewees noted that the activities and materials used to facilitate the demonstration seemed to get the attention of museum visitors, and primarily children and younger visitors, and attract them to interact with the demonstration. Using athletic and toy balls of various sizes and colors, in conjunction with the element of moving air generated by the use of a fan creating sounds and motions (as well as the intentionally playful, and at times possibly chaotic, nature of the demonstration that occasionally led to balls leaving the immediate demonstration area), visitors became interested and were drawn to the demonstration's activities.

Key findings related to *Visitor Learning* surrounded the concepts linked to the different paths and impacts on volcanic fallout during volcanic eruptions. All three participants noted that many visitors learned that fallout includes more than smoke and ash, including pebbles, boulders, and different kinds of ash, and their paths differ during eruptions based on a variety of factors such as size, shape, density or weight, wind, and turbulence, which were represented in the demonstration by the various ball types and impacts of the wind produced by the fan. For *Impacts on Visitors*, all three participants commented on the value in providing opportunities for public audiences to meet and interact with scientists that conduct research. The researchers believed their presence and role as a scientist helped to not only communicate the scientific context that was the basis for the demonstration, but also answer questions and engage in dialogue with visitors about the scientific content in order to deepen their understanding and also perhaps contribute to their increased interest in science and STEM more broadly.

The *Impacts on Scientists* captured reflections of the researchers' experiences with facilitating the demonstration with public audiences at the museum. Although one participant reported that they enjoyed their experience overall, they were unable to recall any noteworthy memories or larger, more general impacts or takeaways. The other two participants made comments about the important role that scientists play in connecting general audiences with scientific information, and how valuable these opportunities and interactions can be in bridging the divide between research and the public. One of the graduate student researchers also found great value in the experience of communicating science with such a diversity of individuals from various backgrounds and levels of interest and understanding, especially related to volcanic ash scientific content.

Overall, the *Volcanic Ash* demonstration was an engaging and educational activity that provided visitors with the opportunity to learn more about the sources, paths, and impacts of volcanic ash and other associated concepts related to volcanic activity. The delivery and facilitation of the demonstration also provided the scientists conducting research on volcanic ash with the opportunity to engage public audiences with their research through hands-on activities that promoted learning. Although the effects of the COVID-19 pandemic limited the reach of this demonstration, the visitors and researchers that were able to interact with it during its delivery at the museum gained valuable knowledge and experiences related to the science and scientists behind volcanic plume research.

Bibliography

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WSUV Volcanoes Evaluation Interview Guide

Purpose:

OMSI is conducting an evaluation for the project "Collaborative Research: Measurement of Particle Aggregation in Laboratory-scale Flows for Improved Models of Ash Fallout and Entrainment," led by PI, Dr. Stephen Solovitz with Washington State University Vancouver. Given the impacts of the COVID-19 pandemic on this project and the broader impacts education projects and public engagement activities, these evaluation efforts focus on the demo facilitators rather than the general public to gather insights on how the demo was engaging, educational, and meaningful, as well as the impact presenters perceived they had by interacting with the public in person.

Activities:

The evaluation activities will include three one-on-one interviews conducted by OMSI Research & Evaluation Associate, Todd Harwell, with the project PI, Dr. Stephen Solovitz, and two previous project associates and demo facilitators. Each interview will be conducted remotely via Zoom and will be audio recorded in addition to the interviewer taking notes. The interviews should last approximately 30 to 60 minutes.

Interview questions:

1. To begin, could you describe your role and how you got involved in the Volcanic Plumes project?
2. In your own words, how would you describe the structure and purpose of the Volcanic Plumes Meet a Scientist demonstration?
3. What do you think drew visitors in to interact with the demonstration?
    a. What did you see, hear, or otherwise experience during delivery of the demo that informed your response?
4. What do you think was the most interesting or exciting thing visitors did or discovered during the demonstrations?
    a. Are there any sources of evidence or collected feedback that have informed your response? If so, please describe those.
5. How do you think visitors would describe the demonstration(s) to a friend or relative?
6. What do you think were the main take-aways or new things learned by visitors that interacted with the demonstration?
    a. What did you see, hear, or otherwise experience during delivery of the demo that informed your response?
7. What do you think were the most confusing or challenging elements or activities of the demonstration for visitors?
    a. What did you see, hear, or otherwise experience during delivery of the demo that informed your response?
8. What particular value or enrichment do you think was offered by having a scientist interact with visitors through this demonstration?
    a. What did you see, hear, or otherwise experience during delivery of the demo that informed your response?
9. Is there anything else you would like to share about how and[/or] why you believe the experience of interacting with the demonstration and you, a scientist, was engaging, educational, meaningful, and/or impactful for visitors?
10. Thinking back on your experiences of facilitating the Volcanic Plumes demonstration, what is one memory, if any, that stands out as particularly meaningful for you as a scientist communicating with public audiences?