Identifying research paths collectively: Analysis of Project Partner Data Maps

Prepared by
Justin Reeves Meyer, Laura Weiss, Donnelley Hayde, Joe E. Heimlich, and Martha Merson
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Abstract

During an in-person meeting for the Sound Travels project, we (the Center for Research and Evaluation at COSI team) asked our project partners from diverse informal learning institutions and job backgrounds to help us identify important paths for our research, given the existing set of data and measured constructs from the previous year of data collection. To do this, we facilitated a data mapping activity. Analysis of 26 of these 'data maps' suggests that people in the Sound Travels project team are most interested in exploring correlational and predictive relationships between visitors' cultural and experiential backgrounds and their visitors' soundscape preferences. A frequency analysis identified nine construct relationship pairs that 'stick out' from the rest of the 81 identified relationship pairs. These are a good place to start for the subsequent analysis phase. We found several new constructs and over 60 relationship pairs that warrant more discussion and consideration as we proceed with the research.

Background of the Sound Travels project

In collaboration with TERC and informal learning organizations across the United States, COSI's Center for Research and Evaluation (CRE) is part of an NSF-funded project, *Research to Understand and Inform the Impacts of Ambient and Designed Sound on Informal STEM Learning*. Known informally as *Sound Travels*, the project brings together a collaboration of informal STEM learning (ISL) researchers, designers, and educators to 1) broaden the research foundation for sound design in ISL experiences, and 2) develop design recommendations for informal learning institutions. Along with other project research partners, CRE is working to address the following research questions over the course of the four-year project:

R1: *How are soundscapes used by ISL practitioners?*

R2: *What are the qualities of soundscapes at different ISL sites?*

R3: *How do informal learners at ISL sites experience sound? To what extent does sound impact attention attraction, dwell time, and shared learning in these learners?*

R4: *How do qualities of the soundscape correlate with indicators of learning: attraction, attention maintenance, and shared learning?*

Following the philosophical value of providing research that is *in service to practice*, the project PI's from TERC, COSI, and Northwestern convened Sound Circles, or times when all members of the project team (i.e., everyone who contributes work toward the project in any capacity or location) have the opportunity to meet to talk about the current state of the research and help guide the direction of the research moving forward. In Year 2, in addition to Sound Circles, team members participated in a September in-person meeting in Chicago. Chicago partners hosted the meeting, while the TERC team and PI Merson took responsibility for presentations and facilitation.

The Chicago meeting context, Year 2

The in-person Chicago meeting took place from Wednesday, September 24, to Friday, September 26, 2024 with the following goals:

1) Provide space for partners from different sites to reconnect informally during meals and optional activities, and formally during structured meeting times.
2) Update all team members on the progress of the research project. This included sharing programmatic elements developed during Year 2, visitor data collected during Year 2, and sound data collected during Year 2.
3) Collectively interpret some of the visitor data collected in Year 2.
4) Collectively experience sound in informal STEM learning spaces throughout Chicago.
5) Work in groups and individually to identify analysis paths of the visitor and sound data that are of interest or use to informal STEM learning educators.
6) Work in groups and individually to identify any gaps in the data and current research plans, as well as ways to improve data collection for Year 3.

As attendees gathered in Chicago on Wednesday, September 24, they were invited to optionally spend the afternoon exploring the Lincoln Park Zoo or Solidarity Studios. Those who chose to participate at either site were also encouraged to consider the ways they encountered sound during their experience.

Twenty-six individuals participated in two days of structured meetings (Thursday, September 25 and Friday, September 26). The group included representation from the following groups:

- three project staff members from TERC
- two project staff members from Northwestern University
- four project staff members from COSI's Center for Research and Evaluation (CRE)
- the project evaluator (Deedrick Consulting)
- seven project partners from the Columbus research sites (COSI, Franklin Park Conservatory, Metro Parks, and the Columbus Zoo and Aquarium)
- three project partners from the Chicago area (North Park Village Nature Center and Solidarity Studios)
- two project partners from Detroit (Wild Indigo and Neighborhood Art School)
- two project advisors from the Chicago area (Hispanic Access Foundation and Midwest Society for Acoustic Ecology)
- two invited guest presenters (sharing sound research findings from Northwestern University and University of Wisconsin–Madison)

On Thursday, the meeting took place at Northwestern University. To recap the work to date, attendees were invited to create a "human timeline" of the project, in which each participant was asked to represent an effort to which they contributed with a sound effect and/or physical motion. Next, attendees participated in an activity in which each person commented on their individual relationship to different types of roles and work (e.g., using sound, gathering feedback on visitor experiences) with rotating conversation partners. The project research team was asked to present preliminary questionnaire data and help attendees explore and begin to interpret it. To support this conversation, CRE Co-PI Justin Reeves Meyer and TERC team member Elise Levin-Güracar prepared R outputs, including some initial visualizations, detailing observed relationships between different variables in the cross-site visitor data gathered in spring and summer 2024. They also provided participants with a packet of materials for use across the two days. This packet included a copy of the visitor questionnaire, a codebook detailing the meaning and structure of different variables in the questionnaire data set, and an explanatory diagram of the format for working with visitor data from the research team's Sound Search protocol. Attendees were invited to annotate the data visualizations with post-it notes. Then they split into small groups to make observations about the data and try to communicate their initial interpretations in a variety of ways, including verbal takeaways and visual demonstrations (e.g., having people stand to show proportions of the sample). Following this exercise, TERC team member Nick Hristov and Detroit project partner Billy Mark (Neighborhood Art School) co-presented an interactive demonstration of directionality within examples of immersive sound. During the day's lunch break, attendees were invited to participate in an adapted version of the research team's Sound Search protocol, in which they were invited to identify and record their own examples of sounds that made them feel certain ways (e.g., curious, uneasy); these sounds were shared and discussed later in the afternoon. The afternoon also included guest presentations from researchers Annie Chu (Northwestern University) and Hanbing Liang (University of Wisconsin–Madison), each of whom shared findings from their studies of sound. Following these presentations, attendees were given the opportunity to discuss and ask questions in small groups.

On Friday, the meeting took place at North Park Village Nature Center. The morning was devoted to exploring technical aspects of sound in context. First, Cesar Almeida (Solidarity Studios) invited attendees to experience ambient music outdoors in the forest, as well as to observe and interact with a DJ station and hand drums as part of the experience. Next, Eric Leonardson (Midwest Society for Acoustic Ecology) and Dan Shanahan (Northwestern University) introduced technologies for observing and recording sounds in natural environments and shared strategies for visualizing sound from recordings of this type. Attendees then broke into small groups to go on short walks through the park and make field recordings of sounds they encountered. When the groups reconvened, there was a brief review of the recordings and discussion about the experience.

In the afternoon session, the CRE research team facilitated the data mapping activity to surface attendees' working hypotheses and questions about potential relationships between constructs represented by data from visitor questionnaires. There were several purposes for this activity: to leverage attendees' various forms of expertise about the constructs in data analysis, to identify potential priorities for making the research team's analyses as practically applicable and useful as possible, and to identify potential gaps in the data set that could inform plans for future data collection. The process for and results of this activity are described below.

What are data maps, and why did we use them?

The data collected in Year 2 for the Sound Travels project consisted of around 500 hours of audio recordings, around 140 sound searches (visitor-driven recordings and interviews), and nearly 1000 questionnaires measuring nearly 100 variables. Due to the size and scope of the data set, we needed a way to get input/set priorities without expecting practitioners on our project team to immerse themselves in weeks if not months of data analysis. The data map activity provided a way for the project team to identify analysis paths they were interested in, using *constructs* or broad concepts we were trying to capture in our data collection.

Data map activity description

With the goal of identifying analysis paths for the research, as well as gaps and improvements to data collection for Year 3, the CRE research team designed a *data mapping* activity for the project team to complete at the end of the three-day in-person meeting.

The materials for the activity consisted of 18 color-coded cards labeled with the different types of data collected through each method (i.e., Sound Searches, visitor questionnaire, and audio moth recording), blank computer paper, glue sticks, and markers. The labels on the cards matched the codebooks shared the prior day.

Project partners were asked to consider how the types of information might relate to one another and identify hypotheses or questions they would like to explore. Partners worked individually or in small groups to select the data types that make up their hypothesis/question and paste the associated cards on a piece of paper. They were also instructed to add annotations, lines, arrows, or other drawings to describe their hypothesis/question.

After partners created their data maps, Meyer and Levin-Güracar facilitated a group debrief. The group discussed what they could do if they knew the answers to the questions they put on their maps, any types of information they felt were missing from the existing data, and how they want to be involved in data analysis moving forward.

How we analyzed the data maps

The CRE team analyzed 26 data maps by identifying each unique construct relationship, coding the relationship's type, and then counting the number of mentions of each construct and unique relationship. We used the frequency of unique construct and construct relationship mentions as a proxy for the priority the project team gave each.

Identifying unique construct relationships

We identified construct relationships in pairs only, even if a data map contained several constructs simultaneously in relationship with the same construct. In Figure 1, three constructs are written in a chain, with arrows connecting them in a specific order. Instead of writing them all together as one relationship with three constructs, e.g.,

1) Technical Features of ambient sound recordings -> Challenges related to sound -> Demographics

we recorded it as three unique, two-construct relationships:

1) Technical Features of ambient sound recordings -> Challenges related to sound
2) Challenges related to sound -> Demographics
3) Technical Features of ambient sound recordings -> Demographics

Since we want to use these data maps to understand the priorities of the project team with respect to our research constructs, it is more informative to deconstruct longer, multi-construct models. Doing so helps us identify common ingredients of the relationship, instead of the relationship itself. If we did not deconstruct each model, we would have found 26 unique relationships. Instead, we infer that pairs of constructs that appear multiple times in the data maps are of higher priority to the project team.

Sometimes maps did not use arrows or lines to connect constructs together in relationships. In this case, we used annotations or other visible markings to help us identify implied relationships. If we did not see any line/arrow connections or text that implied a relationship between constructs, we assumed there were none. We did not treat constructs placed directly adjacent to one another as a relationship pair unless annotations or markings suggested otherwise.

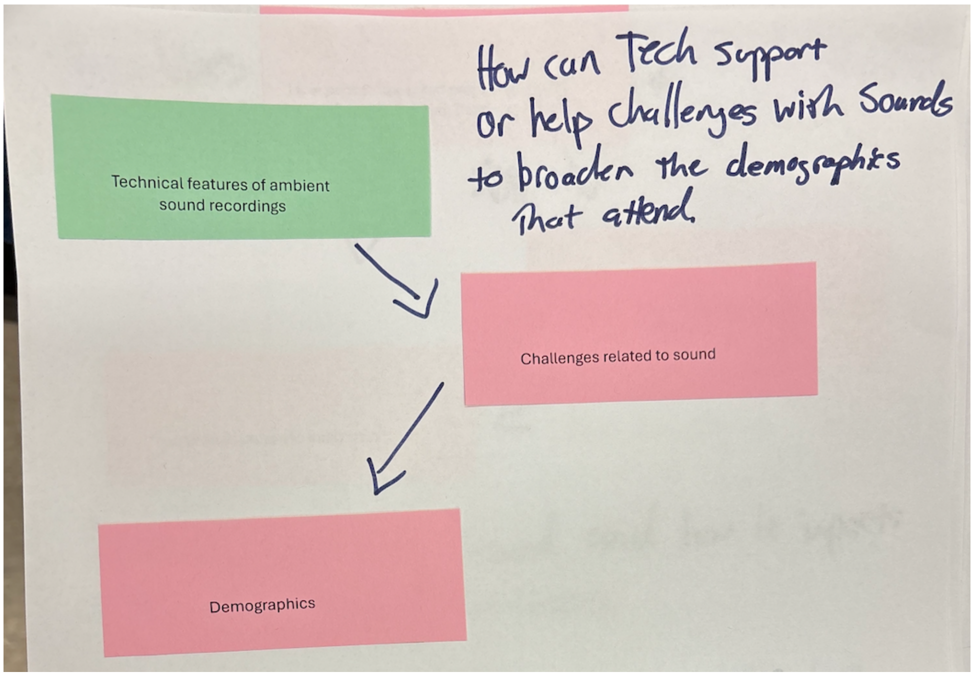

Figure 1: Example of a data map (Name removed to preserve anonymity)

Coding the construct relationship type

Once we identified each unique construct pair relationship across all data maps, we coded for that relationship's type. By default, we assumed that any construct relationship pair was at least suggesting (or hypothesizing) a correlational relationship, whether negative or positive; in other words, we assumed that pairs suggested variables that might change together. If the relationship included an arrow or if there was an implied order to the relationship (i.e., if someone suggested that use construct 1 to know construct 2), we coded that relationship type as a prediction. If there was not only an implied order to the relationship, but a suggestion of an impact (i.e., construct 2 was suggested to result from or be changed by construct 1), then we coded that relationship as causal, or a ‘causation’ relationship.

Counting constructs and weighting relationships

We counted constructs and relationships between constructs by multiplying each mention by the number of people who made the data map. If an individual made the data map, each of the mentions counted once. If the data map was made by a group of three, each mention counted three times. Further, we weighted each relationship by the number of times each construct was mentioned outside of the relationship. We used the following formula:

$$\text{Frequency Weight} = R_i * [C1 - R_i] + R_i * [C2 - R_i]$$

Where:

R_i	is the total number of times relationship 'i' was mentioned
C1	is the total number of times the first construct was mentioned
C2	is the total number of times the second construct was mentioned

To calculate the frequency weight, we first subtracted the total number of times relationship 'i' was mentioned from each construct's mention frequency to get the total number of times a construct was mentioned outside of the relationship pair. Then we multiplied the result for each construct by the total number of times the relationship pair was mentioned and add. This weighting prioritizes relationship pairs that include constructs frequently occurring in other relationships. We assume this would indicate construct relationship pairs potentially of interest to other project team members, even if they did not indicate that particular pairing. The frequency weights for each relationship pairing can be found in Figure 2, in order from highest (1710) to lowest (0) weights. Table 3 contains the five relationship pairs with the highest frequency weights. We only include the five highest weighted pairs to balance

What the data maps show

Out of the 19 different constructs, the most frequently mentioned were soundscape preferences, learning outcomes, cultural relationships to sound, how long [visitors] spent in the zone [i.e., the study area], and how sounds made [visitors] feel during their visit, each appearing no fewer than 21 times each (Table 1).

We identified several new constructs that address new ideas or reflect slight variations in the existing constructs. These included constructs such as Challenges related to sounds, Soundscape preference for completing a nonverbal task, Soundscape preference for reading instructions, Sonic literacy, Cultural literacy, Learning style literacy, Mental health, Healthy relationships, Adaptive learning environments, and Sense of connectedness. We plan to discuss these new constructs and consider whether and how we incorporate them into our data collection for Year 3.

Out of the identified 81 unique construct relationship pairs, the one most frequently mapped was Cultural relationships to Sound and Soundscape Preferences (Table 2). Other relationship pairs that were mentioned more than three times on the data maps include: how sounds made them feel during their visit, learning outcomes, association with music and soundscape preferences, cultural relationships to sounds, sounds they found during their visit, familiarity with the site, and locations where visitors found certain kinds of sounds (Table 2).

Over sixty identified relationship pairs appeared only once or twice across the data maps. For this first step in identifying research and analysis paths for the Sound Travels project, we have focused on relationship pairs that appear at least three times in the data maps (see Table 2). However, we intend to return to these relationships in subsequent phases of the research and continue to keep them in mind as we conduct further analyses.

Using the frequency weighted metric to rank the relationship pairs, the correlation between visitors' cultural relationship to sound and their soundscape preferences is the highest weighted relationship pair (Table 3). Soundscape preferences seem to generally be the most important dependent variable (i.e., the variable affected by something else changing) in the relationship pairs, appearing in the first, fourth, and fifth highest weighted relationship pairs. Not surprisingly, learning outcomes also seem important to the team, appearing in the second highest weighted relationship pair (Table 3).

The distribution of frequency weights for all of the relationship pairs suggests that the top 9 relationship pairs would be an efficient group of focus on first for analysis. When looking at the distribution of all the frequency weights (Figure 2), we see large drop-offs in scores until the 10th pair, when the drop-offs get diminishingly small. While we would ideally look at all of the identified relationship pairs, the last significant drop off in frequency weight between the 9th and 10th pair offers a convenient cut-off for our initial analysis.

Table 1. Frequency of individual construct mentions in the data maps

Construct	# of times mentioned in data maps (weighted by # of people collaborating on data map)
Soundscape preference	25
Learning outcomes	23
Cultural relationship to Sound	21
How long they spent in the zone	21
How sounds made people feel during visit	21
Sounds growing up	15
Association with music	14
Audio of sounds visitors found curious/peaceful/energized/uneasy	14
Demographics	14
Locations within sites where visitors found curious/peaceful/energized/uneasy sounds	14
Group composition	12
Descriptions of sounds visitors found curious/peaceful/energized/uneasy	11
Familiarity with site	10
Awareness of sound current experiences	9
Reasons for visiting	8
How people expected sounds to make them feel during their visit	5
Challenges with sound	4
Technical features of ambient sound recordings	3
Where someone grows up	1

Table 2. Frequency and type of construct relationship mentions in the data maps (those with at least 3 mentions)

Construct 1	**Construct 2**	**Coded relationship type 1->2**	**# of times mentioned in data maps**
Cultural relationship to Sound	Soundscape preference	correlation	6
How sounds made people feel during visit	Learning outcomes	correlation	5
Association with music	Soundscape preference	prediction	4
Cultural relationship to Sound	Descriptions of sounds visitors found curious/peaceful/energized/uneasy	prediction	4
Familiarity with site	Locations within sites where visitors found curious/peaceful/energized/uneasy sounds	correlation	4
Audio of sounds visitors found curious/peaceful/energized/uneasy	How long they spent in the zone	correlation	3
Challenges with sound	Learning outcomes	prediction	3
Demographics	Cultural relationship to Sound	correlation	3
Demographics	Association with music	correlation	3
Demographics	Group composition	prediction	3
Familiarity with site	How long they spent in the zone	correlation	3
How people expected sounds to make them feel during their visit	Learning outcomes	correlation	3
Locations within sites where visitors found curious/peaceful/energized/uneasy sounds	Learning outcomes	causation	3
Reasons for visiting	Learning outcomes	prediction	3
Sounds growing up	Soundscape preference	prediction	3
Sounds growing up	Cultural relationship to Sound	correlation	3
Sounds growing up	Descriptions of sounds visitors found curious/peaceful/energized/uneasy	prediction	3

Table 3. Top 9 ranking of construct relationships by frequency weight

Construct 1	**Construct 2**	**Coded relationship type 1->2**	**Freq. Weight**
Cultural relationship to Sound	Soundscape preference	correlation	1710
How sounds made people feel during visit	Learning outcomes	correlation	1440
Soundscape preference	How sounds made people feel during visit	prediction	874
Association with music	Soundscape preference	prediction	840
Sounds growing up	Soundscape preference	prediction	792
Locations within sites where visitors found curious/peaceful/energized/uneasy sounds	Learning outcomes	causation	660
Sounds growing up	Cultural relationship to Sound	correlation	648
Audio of sounds visitors found curious/peaceful/energized/uneasy	How long they spent in the zone	correlation	594
Demographics	Cultural relationship to Sound	correlation	594

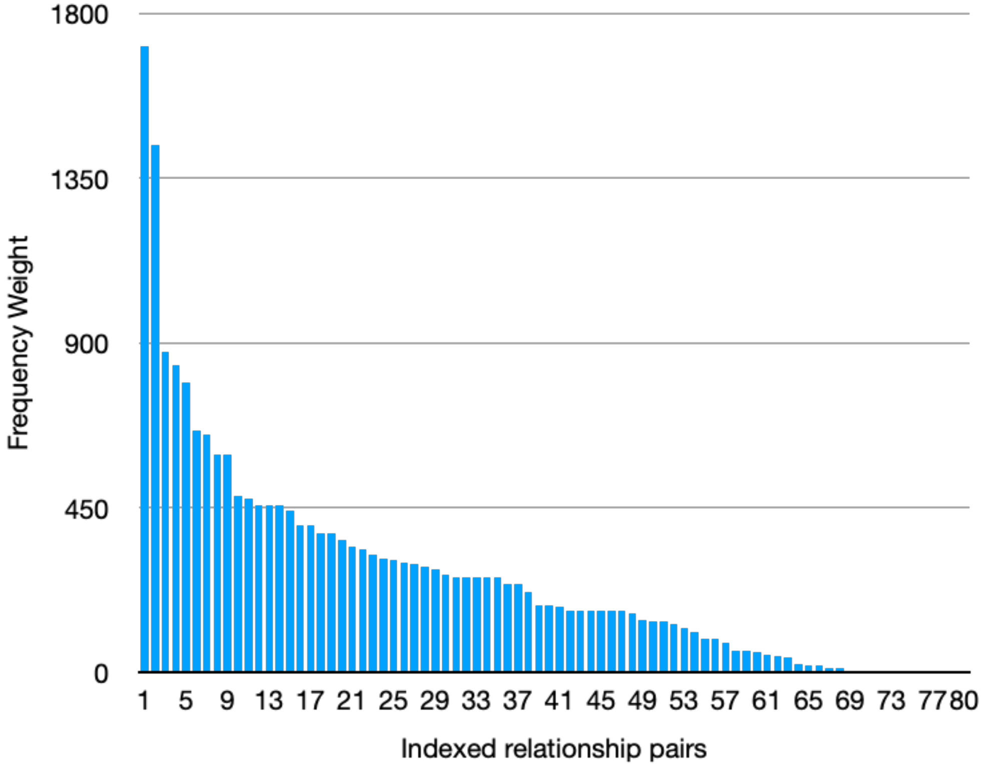

Figure 2: Frequency Weight Plot for all relationship pairs

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