

Dinosaur Hearing Demo

Formative Evaluation

COSI Labs in Life Language Pod

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Background

The Language Pod is part of the Labs in Life in COSI's Life exhibit. It serves as a research space for professors and students at The Ohio State University working in the field of linguistics, and allows COSI visitors to participate in and observe real scientific research. The Language Pod also develops and operates program carts on linguistic concepts for COSI visitors in the main hall outside the Life exhibit. The cart demos are run by Ohio State students as part of a course at the university and explore a wide range of linguistic concepts.

Program carts consist of short, educator-facilitated activities on mobile carts and are conducted outside of the main exhibit spaces. They are regularly operated throughout the halls of COSI by the Labs in Life, as well as COSI staff and volunteers. They can be conducted anywhere in the museum and they are operated for typically 30 minutes to two hours at a time, as they require a demonstrator to facilitate the activity and explain concepts to visitors. Visitors choose whether to engage in the experience or not as they walk through the museum. In some cases they stop at the cart with the intention of engaging in the specific program cart experience, in others something about the demo catches their attention and they come over to explore it.

Dinosaur Hearing Demo

Dinosaur Hearing is a new cart demo developed for the Language Pod that explores how and what dinosaurs could hear, focusing on frequencies of different sounds and how the ear hears them.

Scientists reconstruct the hearing abilities of dinosaurs by comparing fossilized ear bones with those of modern dinosaur relatives, such as crocodiles and birds, and applying basic principles of hearing. Structural differences between the ears of different animals lead to different thresholds of hearing. These thresholds are associated with frequency and mean that different animals can hear different levels and ranges of pitches. It is estimated that dinosaurs likely had a range of hearing between 600 and 3,000 Hz, considerably lower and more limited than the typical human range of 20-20,000 Hz.

This demo teaches visitors what dinosaurs could hear, as well as provides an opportunity to examine how hearing works and compare hearing across different types of animals.

The learning objectives of the demo include:

- **Main objective:** Frequency is an important component of hearing, and different animals hear different ranges of frequencies.
- By looking at fossilized remains, scientists can reconstruct the frequencies extinct animals such as dinosaurs likely could have heard.
- Other animals such as humans, whales, and dogs have their own unique hearing ranges based on their own ear morphologies. These ranges can be compared to dinosaurs to look at how hearing varies across the animal kingdom.
- The hearing abilities of dinosaurs have implications for their communication abilities. They

imply that dinosaurs did communicate through sound, and that those sounds were of lower frequencies.

The demo is conducted using a program cart. Several different components can be used throughout the demo. Comparisons of dinosaur and human cochleae models and the basilar membrane video can be used to demonstrate how the cochlea picks up frequencies and how different cochlea shapes affect what animals can hear. The spectrogram app is used to help visualize frequencies. The frequency comparison magnet board is used to contextualize the hearing of dinosaurs by providing a comparison of dinosaur and human hearing ranges and mapping out common sounds to see whether dinosaurs could hear them or not.

Three different versions of the activity were tested throughout the process:

Version 1: Comparison Chart

In the first iteration of the activity the primary steps of cochlea model comparison, spectrogram, and frequency comparison board were followed. However, the frequency comparison board was a printout and was talked about by the demonstrator, rather than used as a hands-on activity.

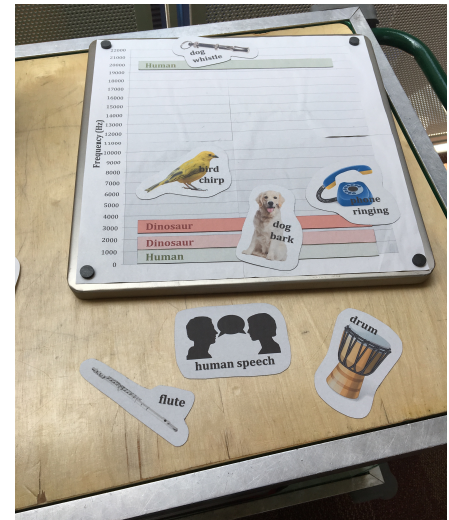


Version 2: Basilar Membrane Video

In the second version of the activity, the basilar membrane video was added to demonstrate how the basilar membrane worked and its impact on the frequencies different animals could hear. This was a more specific and focused topic that involved greater discussion of ear anatomy. All of the other steps remained the same.

Version 3: Hands-On Comparison Chart

The third version of the activity involved a more hands-on experience, and the frequency comparison chart was turned into a magnet board in which visitors could place various sounds and the hearing ranges of dinosaurs and humans on the chart themselves as they assessed where they belonged.



Version 4: Dinosaur Focused

The fourth and final version of the activity sought to focus on the dinosaur aspect of the lesson by framing the activity more centrally around dinosaurs' hearing. By first discussing what could be used to study dinosaur hearing – bones or comparisons with related animals, for example – the rest of the activities including the cochlea models, the spectrogram, and the frequency comparison board were made to revolve around the central idea of reconstructing dinosaur hearing.

Evaluation

Objectives

The objective of this evaluation was to understand visitors' reactions and learning outcomes regarding Dinosaur Hearing and to utilize that information in the further development of the demo.

This evaluation aimed to observe and understand:

- Whether visitors understood how to complete the activity
- How visitors physically interacted with the activity

- Whether the activity difficulty and length were appropriate for COSI visitors
- Whether visitors found the activity enjoyable
- Whether the intended educational message of the demo was coming across

Methodology

This evaluation consisted of a brief verbal questionnaire conducted with visitors after completing the demo, as well as the taking of observational notes on visitor demographics and activity experiences by the demonstrator after each trial. The questionnaire was given to the group as a whole, thus each response reflects the experience of the collective group, regardless of size or makeup. All demos and questionnaires were conducted by the author.

The demo was done on a program cart, and the evaluation questionnaire was conducted at the cart immediately after the completion of the activity. The cart was located in the hallway outside of the Life exhibit and operated during regular COSI hours on weekends. The evaluations were conducted once a week from April 2018-June 2018.

Participants were recruited when they came over to try out the demo. Before the demonstrator began, they told the visitors that the demo was currently in development and asked if they would be willing to answer a few brief questions when they had completed it to help further improve the experience. They were told that if they did not want to answer any questions, or wanted to stop answering questions at any point, they were allowed to do so. If visitors agreed to be surveyed they were asked the questions verbally and the demonstrator recorded their answers. The demonstrator also made observational notes on the experience. If visitors declined to be surveyed, the demo was still conducted but no questions were asked, though the demonstrator made notes reflecting on the experience. The demonstrator never referred to herself as the creator of the activity and described the demo as though she was testing it for the Language pod to avoid influencing visitor's responses.

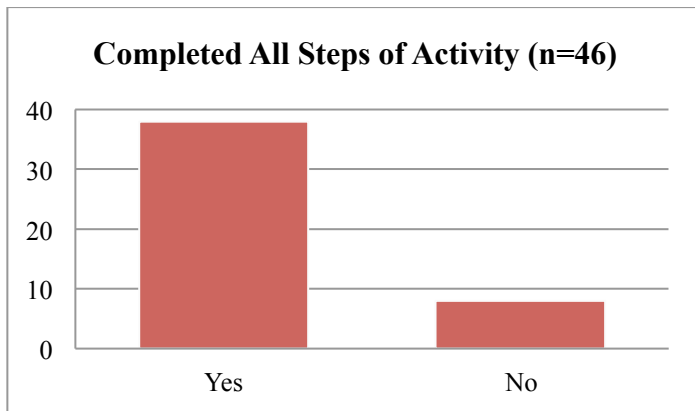
The questionnaire gathered demographic information including number of visitors doing the demo (the demo was almost always done by a single group of visitors who had come to the museum together, e.g. a family, a couple), the ages of the visitors in the group, and the group's relationship to one another. This information was gathered/estimated observationally by the demonstrator and was not specifically asked of the visitors. It was collected to determine whether the activity was effective for different ages and group makeups. Activity related information was also recorded in order to determine visitors' ability to do the activity and interest in continuing with it. The post-activity visitor questionnaire consisted of four open-ended questions. They were meant to assess visitor's enjoyment of and ability to complete the activity, as well as whether the learning objectives of the demo were coming across as intended. After completing the demo and, if conducted, the questionnaire, the demonstrator answered a series of nine questions reflecting on the experience. They recorded the logistics of the demo, if and how visitors completed the activity, and the level of engagement groups of visitors had with one another.

Results

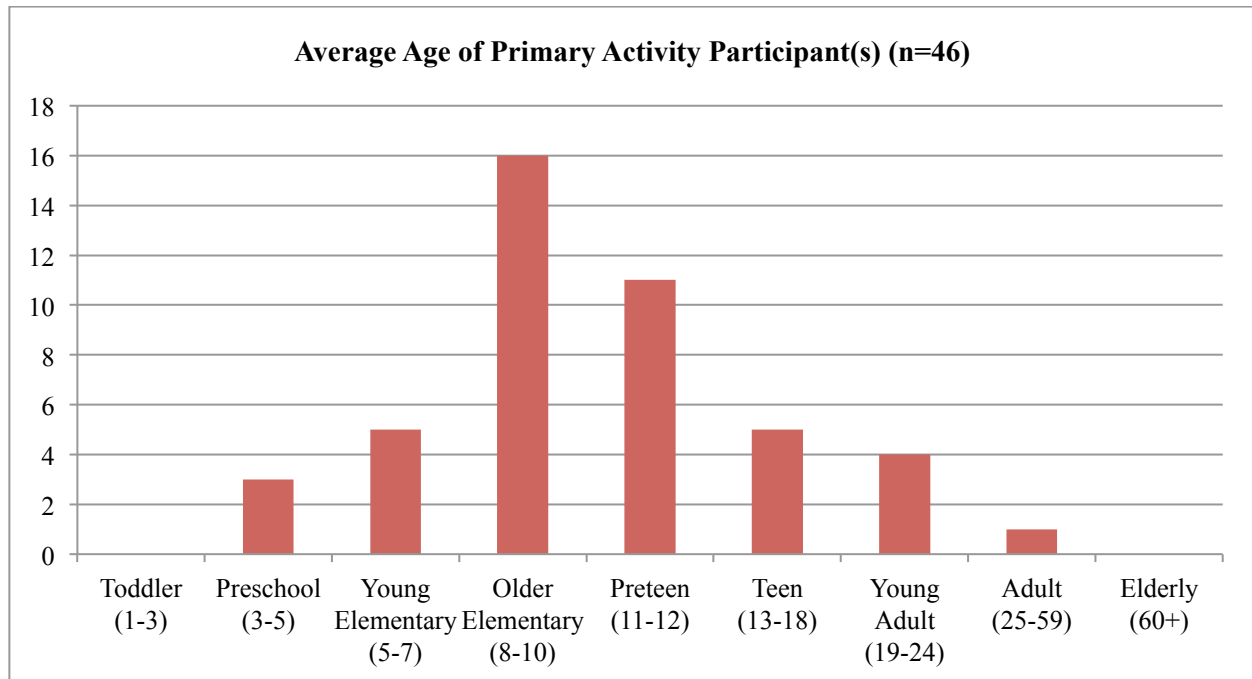
The following results come from 46 trials of the Dinosaur Hearing demo. Demonstrator notes were taken for each trial. Visitors agreed to and questionnaires were conducted for 40 of the trials.

General

Overall, participants were successful at completing the activity by themselves or with some assistance. While some participants did not complete all steps of the activity, they all completed at least one part of it. The many components of the activity lent it to this outcome; however because the many components were designed to be flexible they allowed participants to learn something from the components they did complete.

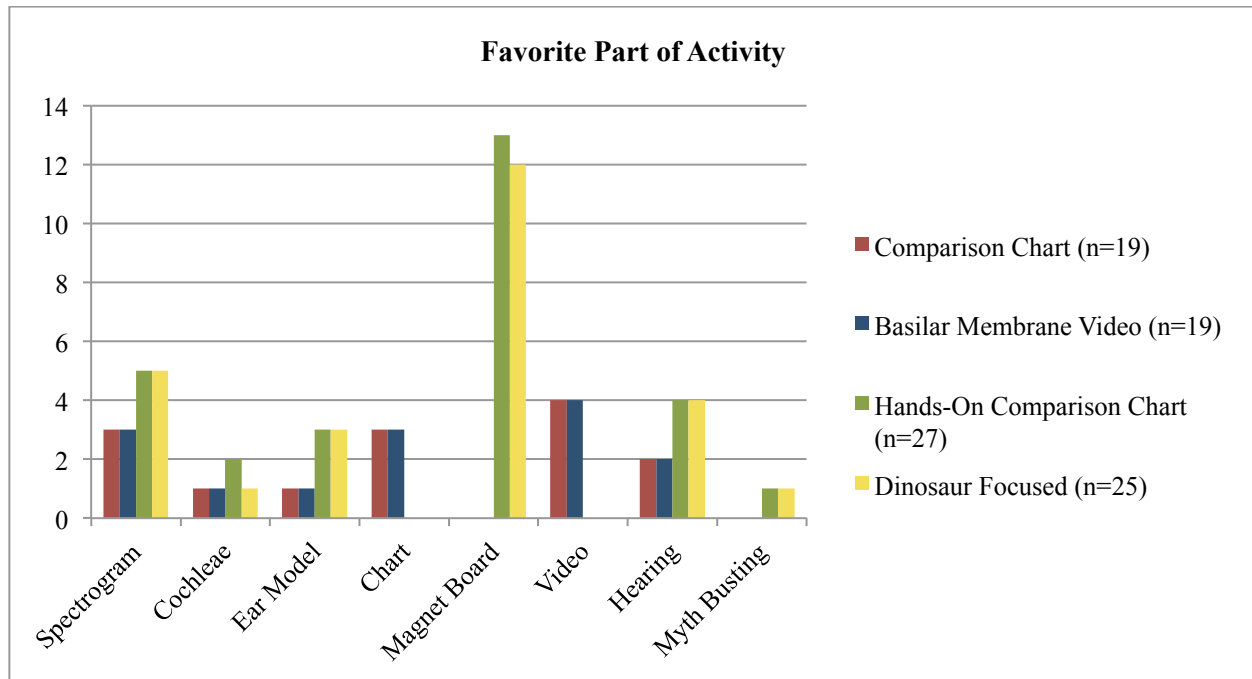


A range of different groups, from individuals to families, did the Dinosaur Hearing demo. Participant's ages averaged around 8-12, the standard age of COSI visitors and the primary audience this cart is intended for. However, the biases of this group should be kept in mind across the following results, as the demo will also be used for both younger and older audiences who may have different needs or interests.



Participant Post-Activity Questionnaire

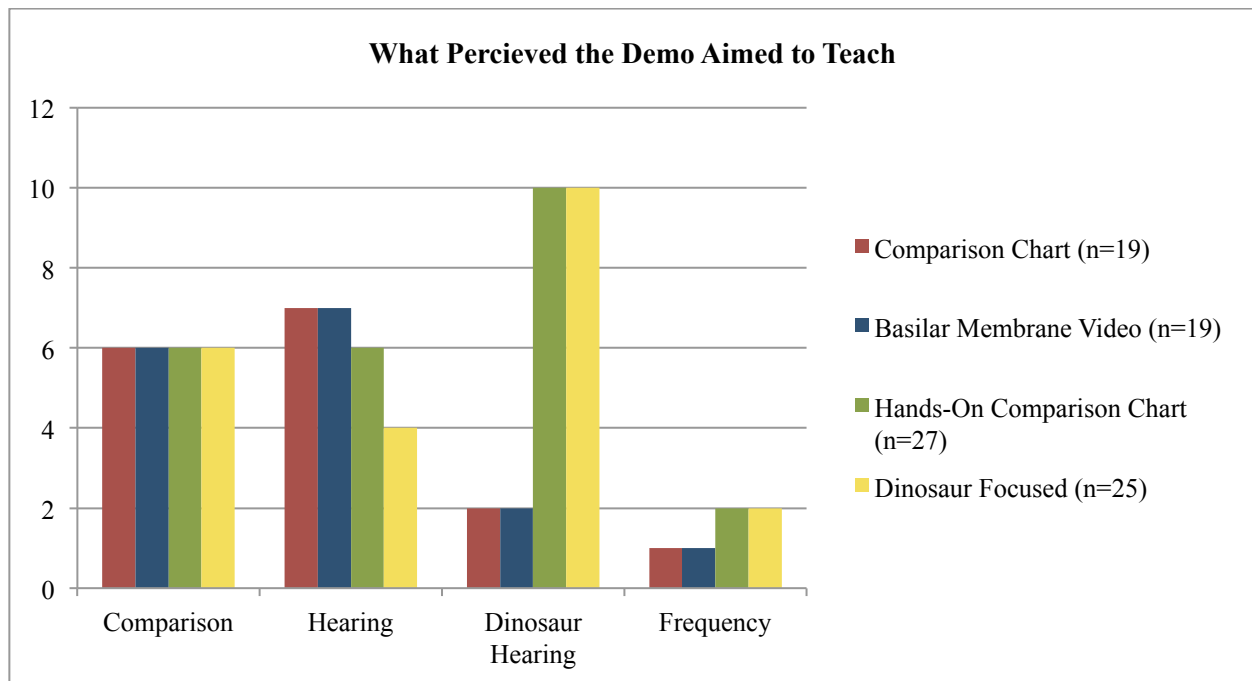
Participant's favorite parts of the activity tended to vary by personal ability or interest, but the information was collected to see what aspects of the activity were enjoyable and which if any, should be expanded upon to promote greater enjoyability and engagement. In the first two versions of the activity, both of which used the comparison chart, the chart was not especially popular. However, in the latter two versions, which used the interactive magnet version of the chart, the magnet board was extremely popular. This suggests that the addition of an interactive element made this component more enjoyable and memorable for visitors. Overall the magnet board and the spectrogram, the two most interactive components of the activity, were the most popular, further supporting this idea. Several visitors mentioned that they enjoyed learning about hearing, which suggests that the topic is of interest. The basilar membrane video was fairly popular in the versions it was used in, thus it has been retained as an optional component in the final version.



The following terms were used to group and code open-ended responses:

- **Spectrogram** – making noises and observing them on the spectrogram to learn about pitch
- **Cochleae** – seeing and comparing the dinosaur and human cochlea
- **Ear Model** – observing and interacting with the human ear model
- **Chart** – seeing the sounds and hearing ranges mapped out on the chart
- **Magnet Board** – interacting with the chart and guessing what sounds could be heard
- **Video** – seeing the basilar membrane video
- **Hearing** – learning something about hearing
- **Learning** – learning something new
- **Myth Busting** – learning something that they thought was true about dinosaurs was not true

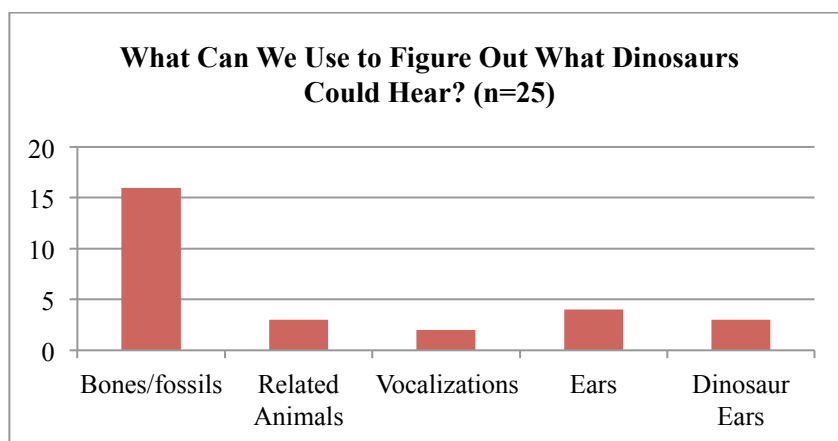
Visitors were asked in the questionnaire what they felt the demo was trying to teach them. The most common responses included how and what dinosaurs hear, and how dinosaur hearing compares to the hearing of other animals. The “dinosaur hearing” responses were fairly general and did not express a deeper understanding of how dinosaur hearing is related to basic biological principles. However, the large increase in their mention for the latter two versions of the activity does suggest that attempting to refocus the activity on dinosaurs by altering the framing of the components was successful. Positively, a significant number of participants did focus on comparisons as well as universal hearing principles, which shows that the deeper messages were being communicated successfully. Though a minority, the mention of frequency as a learning aim of the activity shows that the submessages of the activity were also being communicated well.



The following terms were used to group and code open-ended responses:

- **Comparison** – how the ears of different animals are similar; the morphological features that result in different hearing ranges
- **Hearing** – how the ear and hearing works
- **Dinosaur Hearing** – how and what dinosaurs hear
- **Frequency** – what frequency is and what it means for hearing

Part of the Dinosaur Focused version of the activity involved asking participants an initial question: “What can we use to figure out what dinosaurs could hear?” The following data shows their responses. All of the answers given were able to be worked into the activity, from the most common response of fossils, which lead directly into the dinosaur cochlea model, to related animals and ears in general, which could be used to begin talking about how the dinosaur cochlea compared to those of other animals. The strength of the responses from participants show that this is an effective tool to frame the activity around dinosaurs.



Throughout the evaluation process, participants offered several suggestions for the improvement

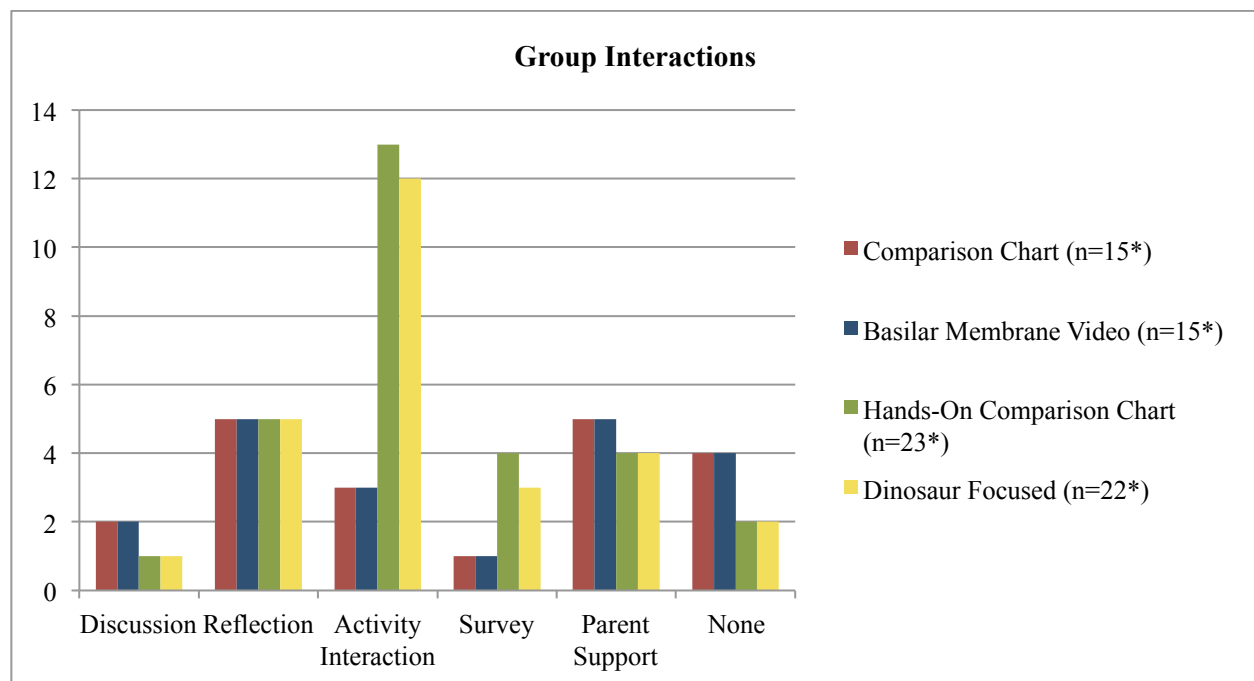
of the activity.

An early suggestion that was utilized was to make the paper frequency comparison chart more interactive. Participants suggested creating an audio chart where a sound could be heard for each of the different points of interest to give a better idea of what they are. While this proved to be too complex, a hands-on version of the chart was created that provided a more tactile, interactive experience than before.

Another suggestion was to have cochlea models for other animals to show another point of comparison for the same feature. Dogs were suggested because their vocalizations and hearing were the topic of two of the sound points for the frequency chart, as well as the fact that their longer cochleae would provide another extreme through which to illustrate the hearing principle being discussed.

Demonstrator Reflection Questionnaire

Group interaction can be hugely beneficial for promoting deeper engagement and learning, and thus the interactions among participants who did the demo in groups were observed. Ultimately, groups interacted at different levels (ordered in the table below from highest to lowest depth of interaction). Activity Interaction was low in early versions of the activity, likely because they did not include hands-on components in which participants could interact. However, with the addition of interactive elements such as the spectrogram and magnet board, intergroup interaction increased greatly. Parent support was common, as many parents prompted their children to answer questions, but did not actively play with them or try and figure out the communication strategy. While post-activity discussion amongst group members about the activity was low, an encouraging number of participants asked further questions and/or reflected on the topic in conversation with the demonstrator.



*number of participants who participated in a group of 2 or more

The following terms were used to group and code open-ended responses:

- **Discussion** – discussed what they had learned with one another after completing the activity
- **Reflection** – asked further questions about the activity; discussed a related topic
- **Activity Interaction** – interacted with the activity together by making sounds, guessing, etc.
- **Survey** – participants did not actively participate together, but they did answer questions about the demo together
- **Parent Support** – parents encouraged or prompted children to answer questions, but did not actively participate in the activity or answer questions with them
- **None** – participants did not interact with each other in the activity

Interpretation and Application of Results

The results of this evaluation helped to develop a better understanding of how visitors related to the Dinosaur Hearing demo and what they learned from it. Overall, the results largely confirmed the logistical efficacy of the demo. They also present implications for the future operation of the demo, as well as how the lesson may be integrated into other demos.

Both the participant and evaluator questionnaire sought to evaluate whether the demo worked from a practical standpoint, including whether participants understood what they were being asked to do, whether or not it was too difficult, and whether or not they did the activity in the way it was intended.

Early versions of the activity faced issues with interactivity, as they involved little to no components that participants could interact with themselves. This led to lower engagement and likely understanding. Changes were made to improve on this and components were altered or added that allowed participants more opportunities for hands-on learning. These changes proved to be successful, leading to improvement in the areas of group interaction and targeted learning outcomes.

The results indicate that logistically the demo worked well and that participants faced little difficulty completing the activity. They were typically active in engaging with various components such as the frequency chart and spectrogram, and they shared ideas and asked further questions throughout the demonstration and evaluation.

At the conclusion of this evaluation, the following recommendations leave room for further development and improvement of the demo.

The comparison of hearing between different animals proved to be an area of interest for visitors, and the addition of cochlea models and a discussion of hearing in animals such as whales or dogs would likely be popular.

This demonstration is highly flexible and can be done a variety of different ways to emphasize different points. It also provides a great addition to other language pod demos. The ear or cochlea model could be elaborated on by providing an example of the cochlea in different species of animals and discussing the outcomes of the differences between the species. The frequency magnet board is also a great hands-on tool to accompany the spectrogram, as it can help visitors to put different frequencies in context by matching them up with the sounds they hear everyday.

References

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Appendix: Questionnaire

The following form was utilized to evaluate visitor's experiences with Dinosaur Communication.

COSI Labs in Life Language Pod Demo Formative Evaluation

Participant Questionnaire

Number of participants in group: _____

Age(s): _____

Gender(s): _____

Relationship to each other: ☐ family ☐ friends ☐ other: _____

1. What was your favorite thing about this demo? What was your least favorite thing?
2. Did you find this demo difficult or confusing? Why do you say that?
3. What do you think we wanted you to learn from this demo?
4. What could we do to make this demo better?
5. Any further comments?

Investigator Reflection/Observation Questionnaire

1. How was the demonstration physically set up? What were the pros and cons of this?
2. What were participant's initial reactions to the demo?
3. Did participants read/listen to the instructions?
4. Did participants read/listen the background information?
5. What steps of the activity did participants do? Which did they not do? What alternative methods did they use?

Activity Step	Completed	Alternative Method
[Step 1]	Y/N	
[Step 2]	Y/N	

[Step X]	Y/N	
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6. Were participants able to complete the activity? If not, why?
7. If applicable, what kind of assistance did you need to provide to participants so that they could complete the activity?
8. Did participants interact with each other?
9. Did participants discuss what they were doing/had done in the activity with one another?
What did they discuss?