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# Summative Evaluation of *Global Soundscapes: Mission to Record the Earth* Interactive Theater Show + YELL Activities


Report for
Purdue University
Foxfire Interactive

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We would like to thank the staff of the Gulf Coast Exploreum and the EcoTarium for implementing the theater show and YELL activity and thank the students of Mobile, AL, and Worcester, MA, for their participation in the summative evaluation of *Global Soundscapes*.

# EXECUTIVE SUMMARY

Supported by the National Science Foundation, the *Global Soundscapes! Big Data, Big Screens, Open Ears* project employs a variety of informal learning experiences to present the physics of sound and the new science of soundscape ecology. The interdisciplinary science analyzes sounds over time in different ecosystems around the world. The major components of the *Global Soundscapes* project are an educator-led interactive giant-screen theater program and hands-on group activities. Multimedia Research, an independent evaluation firm, implemented a summative evaluation with low income, inner-city minority students at the Gulf Coast Exploreum in Mobile, AL, and the EcoTarium in Worcester, MA. Using observations and post-experience questionnaires, the evaluation assessed the influence on 67 fifth and sixth grade students of a 45-minute interactive, sound-based, giant-screen theater experience followed by 45 minutes of sound-related activities. The general goals of the evaluation were to assess student appeal, engagement and interest; knowledge of the basic physics of sound and soundscapes; and potential future behavior related to soundscape ecology.

## Key Findings of Engagement, Appeal and Interest

**A large majority (85%) of students "liked" or "liked a lot" the *Global Soundscapes* theater show.** Through most of the show, students were observed to be highly engaged with the visuals and were greatly responsive to the presenters' questions and directions; only late in the show during the Mongolian video did attention begin to lag. Students most liked learning new information about sound (24%), hearing different sounds (19%), and audience participation (18%). Some students noted discomfort with specific visuals such as the raspberry-making faces and vocal cords (17%) or discomfort with the theater environment (14%). By integrating a live educator into presentation of the film, this program is unique in the world of giant screen films and its appeal is very competitive with traditional giant screen films. Looking at quantitative appeal results from student summative evaluations of 11 NSF-supported giant screen films, we note that students in this evaluation rated *Global Soundscapes* higher in appeal than students viewing 9 of the 11 other STEM films.

**Three-quarters (74%) of participants "liked" or "liked a lot" their post-show activity.** Almost all (91%) Exploreum students liked everything about their hands-on experiments with the physics of sound: blowing balloons, tapping water-filled glasses, and placing vibrating tuning forks into bowls of water. At the EcoTarium, half (52%) of students liked listening to sounds of nature during their walk to two pond areas; another 18% enjoyed the walk itself; and 21% liked seeing animals in enclosures passed on the trail. Some students (39%) took exception to the hilly and bumpy parts of the walk.

**A large majority of students felt that the show and activity experiences increased their interest "somewhat" or "a lot" in five different soundscape topics.** Students reported that their experiences increased their interest "somewhat" or "a lot" in the importance of soundscape ecology (85%), methods and tools of soundscape ecology (80%), how to describe soundscapes (80%), what soundscape ecology is (77%), and how to understand spectrograms (72%).

### Key Findings: Learning

**After their experience, a large majority of students were able to cite correct examples of sounds in all three sound categories of *anthrophony* (95%), *biophony* (91%), and *geophony* (80%). Students understood the term *frequency* (45%-59%) much better than the term *amplitude* (18%). Almost one-third of students could provide the scientists' definition of the *soundscape* as all sounds in a place.** Post-show activities added value to the show, as those students whose activities reinforced specific terms were better able to recall those terms.

**In analyzing soundscapes, students suggested that ecologists identify sounds (22%) or establish physical characteristics of the sounds (21%), but few students (7%) mentioned applying more complex analytical approaches of looking for changes over time or differences by location.**

**Students most commonly felt that the importance of studying soundscapes is to identify sound sources (21%) or to experience sounds and/or nature (12%).** Others felt that soundscapes were important to learn about changes or differences (10%), to hear things we can't see (9%), or to assess biodiversity and health (6%). A good portion (28%) of the students were not able to address the importance of soundscapes.

### Key Findings: Future Behavior

**A large majority of students thought they were "somewhat" or "very" likely to do five different soundscape-related activities after their experience.** Students reported that their experience with the theater show and post-show activities made them feel "very" or "somewhat" likely to listen more closely to sounds around them (88%); to tell others what they learned about soundscapes (83%); to record their own soundscapes (72%); and to go to the iListen website to learn more (60%).

**In conclusion, the science center staff successfully implemented the *Global Soundscapes* theater show and two post-show YELL activities with an audience of low income minority youth to achieve the project's planned outcomes of engagement, appeal, interest, knowledge, and future behavior.**

# INTRODUCTION

Supported by the National Science Foundation, the *Global Soundscapes! Big Data, Big Screens, Open Ears* project presents the science of sound and the new science of soundscape ecology through a variety of informal learning experiences. "Soundscape ecology is an interdisciplinary science that studies how humans relate to place through sound and how humans influence the environment through the alteration of natural sound composition."[1]

Using real-time observations and a post-experience questionnaire, Multimedia Research, an independent evaluation firm, implemented a summative evaluation to assess the influence on fifth and sixth grade students of a 45-minute interactive, sound-based, giant-screen theater experience followed by 45 minutes of sound-related activities. The general goals for the evaluation were to assess student appeal, engagement and interest; knowledge of the basic physics of sound and soundscapes; and potential future behavior related to soundscape ecology.

# METHOD

## Sites and Participants

The full respondent sample of 67 participants comprises 49% fifth graders and 51% sixth graders with 57% boys and 43% girls. Low income, inner city minority students participated in the evaluation at two science centers:

- Gulf Coast Exploreum[2], Mobile, AL, drew 34[3] sixth graders (62% boys) from an inner city public middle school. School statistics report enrollment of 94% African-American students and 79% receiving free/discounted lunch. According to state standardized tests, the majority of students in this school are not proficient in reading and math. The students were accompanied by three female teachers.
- EcoTarium[4], Worcester, MA, drew 33 fifth graders (52% boys) from an inner city public elementary school. School statistics report enrollment of 47% Hispanic and 16% African-American students and 94% receiving free/discounted lunch. According to state tests, two-thirds of students in this school have attained or are progressing toward proficiency in English language arts and mathematics. The students were accompanied by two female teachers and two female chaperones.

[1] http://www.nsf.gov/awardsearch/showAward?AWD_ID=1323615&HistoricalAwards=false

[2] http://www.exploreum.com/

[3] Not included in this number are two Spanish-speaking girls who could not easily read the English survey. To permit them to participate in the evaluation, they answered an alternative short appeal survey in Spanish but they are not included in the report analysis.

[4] http://www.ecotarium.org

## Procedure and Materials

Students at both science center sites experienced 45 minutes of an educator-led participatory giant screen show in a dome theater[5] followed by 45 minutes of YELL[6] activities. The science centers chose YELL activities that best fit their staff experience and institutional setting. Students at the Exploreum experienced hands-on physics of sound activities in a classroom setting; whereas students at the EcoTarium participated in an outside sound walk listening activity. After experiencing the theater show and YELL activities, all students completed a two-page questionnaire.


**The show.** The *Global Soundscapes* theater show follows three soundscape ecology teams in Costa Rica, Hawaii, and Mongolia on their mission to record the sounds of the earth. The interactive show is hosted by a live presenter supported by surround sounds and giant screen images and videos. The presenter at Exploreum was an African-American female (see photo), and the presenter at EcoTarium was a Caucasian female. Joined in the video by a pre-programmed female computer voice, the live presenter guides the audience through four levels of basic training in the science of sound and soundscape ecology with thought-provoking questions, explanations, and audience activity. Evaluators observed student engagement during the show. The show's major content is outlined and illustrated in the results section (p. 4-5).

**The activities.** After the theater show, students at the Exploreum moved to a classroom where they sat at tables set with manipulatives. Their 45-minute experience focused on labs A, B, and C from the Sound Production Activity 1 in the YELL guide. The goal of these labs is to use different materials to produce sound and learn physics of sound terminology. The EcoTarium's 45-minute post-show activity focused on the outdoor Sound Walk activity 7 in the YELL guide. The goal of this activity is to learn to listen actively to a soundscape, categorize sounds, and compare soundscapes from different locations. Presenters modified the activities as appropriate for their site and students. Evaluators observed and recorded implementation of the activities on site. Details of the modified activities are presented in the results section (p. 10-

[5] Trailer for Global Soundscapes available at https://vimeo.com/182787882. Show marketing description: "Immerse yourself in the amazing sounds of our planet! Through giant screen images, surround sound, and live presentation, Global Soundscapes takes you on an ear-opening journey into the science of sound and the emerging field of soundscape ecology. Embark on a mission to investigate the dramatic soundscapes of Costa Rica's rainforests, Hawaii's coral reefs, and Mongolia's vast grasslands. Learn how animals use sounds to survive and communicate in lush, but threatened environments. Understand basic acoustics through interactive activities and incredible slow-motion footage of pulsating musical instruments, vibrating vocal chords, and slobbering "raspberries." Discover what soundscapes tell us about the health of our planet. With Global Soundscapes' unique format—combining giant screen images, surround sound, and live presentation—you'll hear the Earth in a whole new way!"

[6] YELL = Your Ecosystem Listening Labs. For instructor and student guides of all YELLs, visit the Teacher portal at iListen.org

14).

**The post-questionnaire.** A three-page draft questionnaire was developed based on the full set of planned objectives for the interactive theater show and the YELL activities chosen by the science centers. The draft questionnaire was completed in a pilot study by 52 sixth graders who viewed the theater show at Connecticut Science Center but did not participate in post-activities. Based on pilot results, the questionnaire was shortened and revised. The questionnaire included both open-ended and closed-ended questions. To avoid a response order effect, the order of responses for closed-ended questions was reversed for half of the participants. The final two-page questionnaire (see Appendix) focused on assessing three areas of planned outcomes outlined below:

1) Engagement, appeal, and interest:
    a) Engagement in soundscape ecology concepts and methods supported by student interactivity and participation
    b) Interest in soundscape ecology concepts and methods triggered through immersive audio and visual experience
2) Knowledge of sound and soundscape ecology:
    a) Knowledge of sound and soundscape fundamentals including definitions of biophony, geophony, anthrophony, frequency, amplitude, and soundscape
    b) Understanding of soundscape ecology analytical approaches; e.g., looking for patterns, changes over time, differences by location
    c) Knowledge of the importance of soundscape ecology to assess health of an ecosystem
3) Potential behavior:
    a) Likelihood of doing a variety of post-visit activities related to soundscape ecology

Students spent about 10-20 minutes answering the survey. Students who finished early were asked to sit quietly or to draw a picture about their experience on the back of their survey.

## Data Analysis

Quantitative rating responses are presented in frequency bar charts. Due to rounding errors, the bars may not add up exactly to 100%. Non-directional statistical comparisons were implemented for gender (boy, girl) and for the two science center sites (Exploreum, EcoTarium), which also correspond to the two grades ($5^{th}$, $6^{th}$). Statistically significant findings at $p \leq .05$ are reported, meaning that in 5 of 100 cases the result would appear by chance or that there is a 95% probability that the effect truly exists. For easier reading, statistics are presented in footnotes.

Qualitative data from open-ended survey questions were analyzed by keyword and key phrase and sorted into categories pertaining to the main messages of the theater show and activities. Initial sorting was implemented by the first author and reviewed by a second researcher. For easier reading, illustrative quotations from participant responses have been edited slightly, particularly correcting spelling errors.

## FINDINGS: ENGAGEMENT, APPEAL AND INTEREST

### Engagement with the theater show

During the theater show, the audience was observed for behaviors indicating engagement or boredom. **Through a majority of the show, students at both sites were observed to be highly engaged with the visuals and were greatly responsive to the presenters' questions and directions; only during the Mongolian video did attention begin to lag.** Students at Exploreum participated vigorously, shouting out answers and identifications, whereas students at EcoTarium were more decorous, holding up their hands to be called upon. Both groups showed similar patterns of engagement. Table 1 illustrates (left column) and outlines the major content (middle column) of the *Global Soundscapes* interactive theater show and describes student responsiveness during the show (right column).

**Table 1. Engagement with *Global Soundscapes* interactive theater Show**

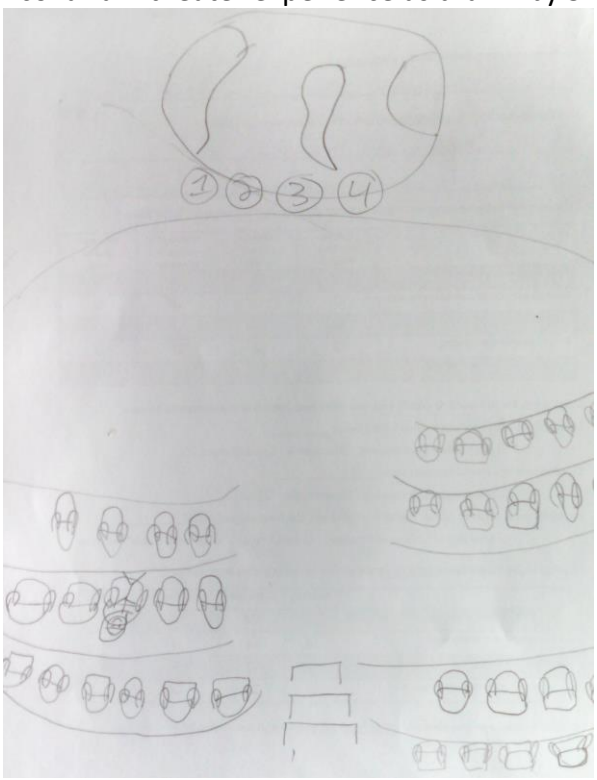
| | | |
|---|---|---|
| Level 1 Training: A soundscape includes all the biophony, geophony, and anthrophony sounds recorded in a place. | | |
| QuickTime™ and a decompressor are needed to see this picture. | Intro to soundscape ecology via audience comparisons of rainforest sounds and landscape in 2008 and 2015. Intro to soundscape terminology with a no-visual listening experience of beach sounds. | Students listened quietly to the sounds and gave their observations of what they heard in 2008 and 2015. Students provided candidates from the beach audio for biophony, geophony, and anthrophony sound categories. |
| Level 2 Training: Concepts of frequency and amplitude. How to analyze a spectrogram | | |
| QuickTime™ and a decompressor are needed to see this picture.<br>QuickTime™ and a decompressor are needed to see this picture. | Video of soundscape ecology team in Costa Rican rainforest. Presentation of science of sound: How sounds are made by vibrations, using cymbal demonstrations and audience participatory activities of raspberry blowing and vocal cord humming. Introduction of terms to describe sound. | Students were excited to identify rainforest animals. [Exploreum students had just completed a rainforest module.] Engagement with raspberry blowing and vocal cord humming activities was strong, with some minor 'ewing' in response to the supporting videos. |
| QuickTime™ and a decompressor are needed to see this picture.<br>QuickTime™ and a decompressor are needed to see this picture. | Introduction of 3D spectrogram tool to study sound, using tuning fork and howler monkey examples, with audience making predictions. | Students paid attention during the presentation of spectrogram visuals; however, audience responses about the frequency, amplitude and level of change of the howler monkey spectrogram indicated some confusion about the terms and how to read the spectrogram. Students noisily enjoyed making a howler monkey sound! |

| | | |
|---|---|---|
| QuickTime™ and a decompressor are needed to see this picture. | Rainforest video presenting analytical research questions of science team. Spectrogram comparisons of 2008 and 2015 rainforest to emphasize that ecologists study sound to assess health of ecosystem and ecosystem changes over time. | [To shorten the program to fit into EcoTarium's time slot, this section was omitted from EcoTarium's presentation.] Exploreum students were attentive and discussed their observations of differences between the two years of soundscapes. |
| Level 3 Training: How animals use sound to communicate. How soundscapes tell us about health of an ecosystem. How noise – anthrophony – can impact animals. | | |
| QuickTime™ and a decompressor are needed to see this picture.   | Video of science team at Hawaiian coral reef. Audience views and listens to videos and associated spectrograms of healthy and less healthy reefs. Analysis of reef spectrogram with motor boat engine sound. | Students attempted to imitate and identify sounds and responded to questions about differences between the two reefs and impact of motor boat engine on fish. |
| Level 4 Training: Soundscape methods in Mongolia. How soundscapes inspire Mongolian traditional music. Ranges of sound of animals and humans, sound beyond human hearing. | | |
| QuickTime™ and a decompressor are needed to see this picture. | Video of soundscape ecology team in Mongolia. Traditional Mongolian throat singing demonstrated and tried out by audience. | Some students were beginning to fidget and show sleepiness during the Mongolian video but attention was regained with the throat singing exercise. |
| QuickTime™ and a decompressor are needed to see this picture. | Analysis of very high frequency spectrogram with audience prediction of animal (bat). Audience participation in hearing range activity. Presenter explains how to continue learning about soundscape ecology via iListen website. Show closes with audience voicing their own soundscape. | Students could not predict which animal makes the ultrahigh frequency sound but recognized the bat when shown. The audience laughed at the false start in the hearing test, and participated with enthusiasm in producing their own soundscape. The Exploreum presenter showed the RecordtheEarth app on her phone while recording the audience soundscape. |

Several students chose to draw their theater experience after completing the questionnaire. Two of these are shown on the next page.

Exploreum theater experience as drawn by 6th grade girl

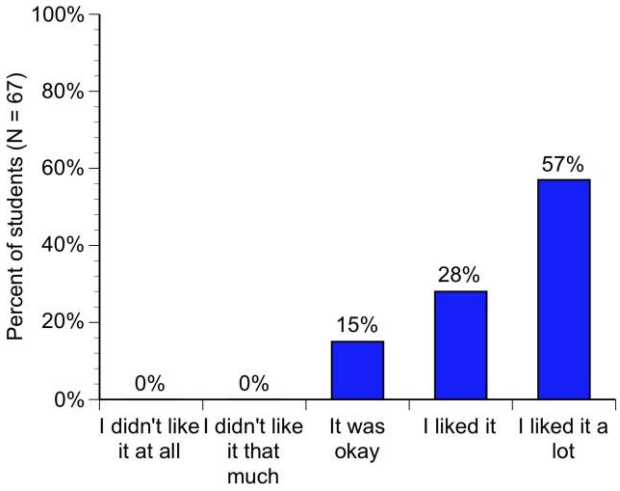

EcoTarium theater experience as drawn by 5th grade girl



## Appeal of the theater show

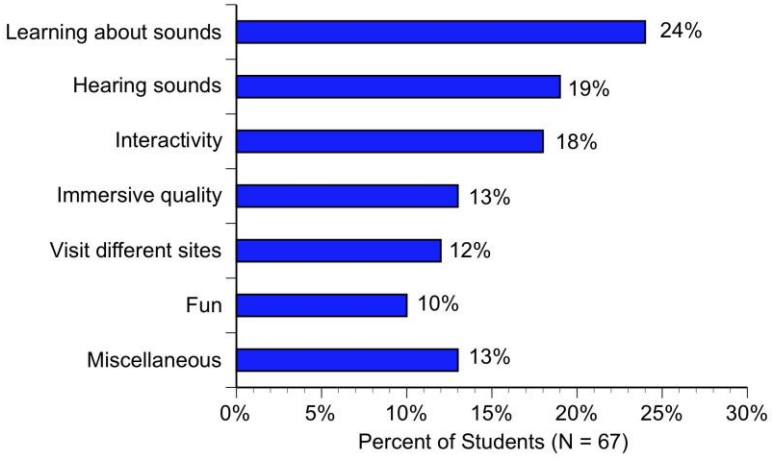
Figure 1 below indicates how much students liked the *Global Soundscapes* theater show: ***85% either liked the show (28%) or liked the show a lot (57%).*** There were no significant site/grade differences or gender differences in show appeal, so Figure 1 presents appeal for the full sample of 67 students.

Figure 1. Appeal of *Global Soundscapes* theater show




When asked what they liked about the theater show, students provided a wide range of responses. ***The theater audience liked most learning new information about sound (24%), hearing different sounds (19%) and audience interactivity (18%).*** Figure 2 presents the percent of students sorted into categories of what they liked about the theater show. Example responses illustrating the categories appear below Figure 2.

Figure 2. What students liked about *Global Soundscapes* theater show




- 24% liked the <u>learning about sounds</u>; for example:
  *I like how the scientist explained the high and low frequencies*
  *How it tells us about the way sound moves and how high and low the pitch is*
  *I like that we learned more about pitch*
  *I didn't know ants could make sounds*

*I like that it explained all the different sounds so I could learn what they are*
*I like how it taught us all types of sounds*
*It taught us about you can hear things without seeing it*

- 19% liked hearing the sounds; e.g.:
  *The sounds*
  *The animal noises*
  *I liked the sounds they made*
  *All the types of sound animals made*
  *I liked it because it showed all the different animals sounds*

- 18% noted audience interactivity; e.g.:
  *The audience interactment*
  *I liked the interactivity*
  *When we had to listen to the sounds and guess where we are at*
  *When we made different noises with our mouth*
  *I liked the parts where we get to tell our perspective on what we are watching*
  *I liked when we made our noise*

- 13% liked the immersive quality. This response was more frequent for EcoTarium students because that theater has a digital fulldome projector that displays the screen image so that it surrounds viewers; whereas the Exploreum's presentation is on a giant but flat display because it lacks digital dome technology.
  *I liked the part that they made it seem like we was with the people*
  *The thing I liked about the theater show is that it felt like it was 3-D*
  *I liked that it was kind of 3-D when zoomed in*
  *I like about theater show was it felt like it was 3-D*
  *How the surround video was appearing on the dome roof*

- 12% liked the various sites; e.g.:
  *It showed us a lot of different places*
  *I liked how it showed us different types of biomes*
  *I liked when we went to Costa Rica and Hawaii because I liked to see the beautiful stuff there*
  *How we got to see under water Hawaii*

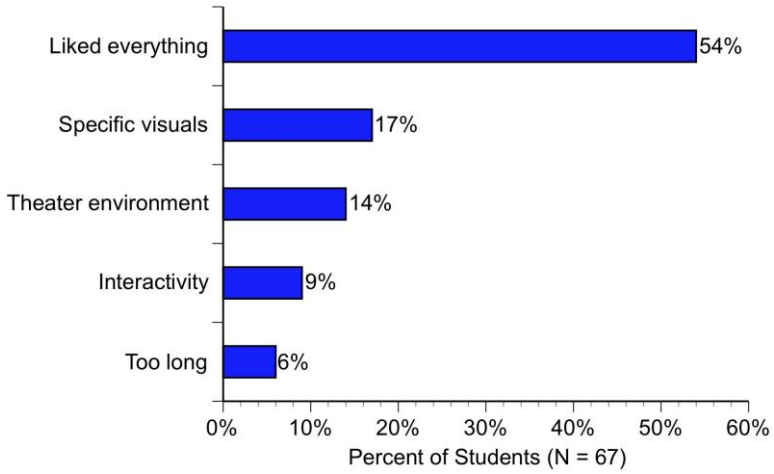
- 10% liked everything because the show was fun; e.g.:
  *All of it! (almost)*
  *It was fun and funny*
  *I like it all because it very fun*
  *I liked all of it. It was fun, very fun*

- 13% gave miscellaneous other responses focused on appeal of the animals (6%), presenter (4%), and mission computer (3%); e.g.:
  *What I liked about the theater show is that it showed me a lot of different animals*
  *Because we saw all sort of animals*

*I like that the lady* [presenter] *was very nice and making good comments about us*
*I like our person who was guiding us through it*
*Mission computer*

When asked what they did not like about the theater show, ***a majority reported liking everything (54%). Some students were uncomfortable with specific visuals (17%) such as the raspberry-making faces and vocal cords, and some students commented negatively about their experience in the theater environment (14%).*** Figure 3 presents the percent of students sorted into categories of what they did not like about the theater show. Example responses illustrating the categories appear below Figure 3.

Figure 3. What students did not like about *Global Soundscapes* theater show




- 54% liked everything; for example:
  *I like all of it*
  *It was great*
  *I like all of it. It was very amazing*
  *I like it all!*

- 17% did not like specific visuals; e.g.:
  *The raspberrys in slow-motion*
  *I didn't like when the people were raspberrying*
  *I didn't like that when I saw one person's throat, it was nasty*
  *I didn't like the throat thing*
  *I didn't like when the bug part came on*
  *I did not like when they showed the bugs*

- 14% noted issues with the theater environment; e.g.:
  *How cold it was in the theater*
  *It was so dark*
  *It was really loud*
  *What I did not like is that the chairs were connected so I did not have an arm rest because people used the arm rest before I could*

*I didn't like that I had to stretch my neck to look at the upper part*
*The lag on the computer*

- 9% did not like some of the interactivity; e.g.,
  *I didn't like when we had to blow a raspberry, because people's spit went in my face*
  *I didn't like the part that it kept pausing every time for a person to talk or for an example of something*
  *The noise at the end part*

- 6% felt the show was too long; e.g.:
  *I didn't like how long it was*
  *It was so long*

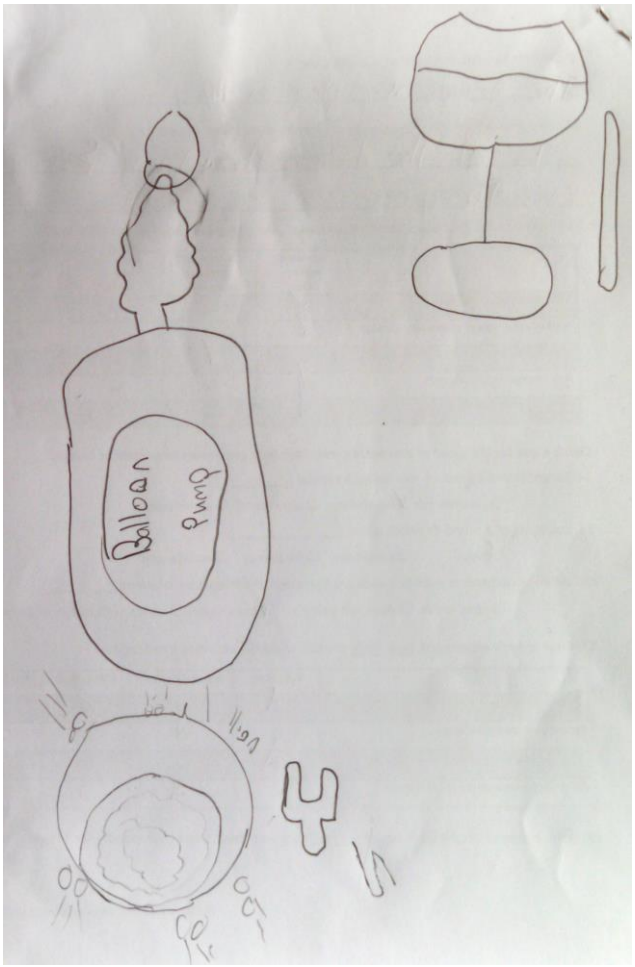
### Engagement with the YELL activity

Exploreum. The YELL activity at the Exploreum involved a 45-minute experience focused on labs A, B, and C from the Sound Production Activity 1 in the YELL guide. The goal of these labs is to use different materials to learn about sound production and physics of sound terminology. In a classroom setting, three staff educators took turns presenting a short interactive talk supported by PowerPoint slides. Content covered sound production by vibration; sound propagation through different media; sound reception through pressure changes; and the terminology of wavelengths, period, frequency (pitch), and amplitude.

The educators demonstrated physics of sound with three different hands-on experiences, and the students tried to replicate the educators' demos with the manipulatives on their tables. In lab A, students blew up balloons to observe the relationship of frequency to different balloon sizes and tensions of balloon openings. The students enjoyed this activity but needed help on how to produce different sounds by changing the tension on a balloon opening rather than letting the air flutter out. The high noise level in the room also made it more difficult for students to hear differences in frequency of sounds by balloon size. In lab B, students blew on glass bottles or tapped glasses filled with different amounts of water to produce sound with different frequencies. Tapping glasses to make sound was easier than blowing on bottles but students clearly understood what to do in both situations. In lab C, students struck a tuning fork on the table and quickly moved it to a bowl of water, observing how vibration can move water molecules. This activity was highly engaging, with students competing to see who could make the water jump the highest and farthest, and experimenting with hard and soft taps of the tuning fork. After each hands-on activity, an educator asked the group about what they observed and summarized the takeaway lessons of the activity. A student drawing of this activity follows.

In a debriefing with the educators, they mentioned that glasses should be included as an option to bottles in lab B and that it would be useful to have access online to images that are in the guides in jpg format for inclusion in PowerPoint slides. The educators also noted that their tuning forks differed in quality of holding a vibration.

Drawing of Exploreum sound production activities by 6th grade boy.

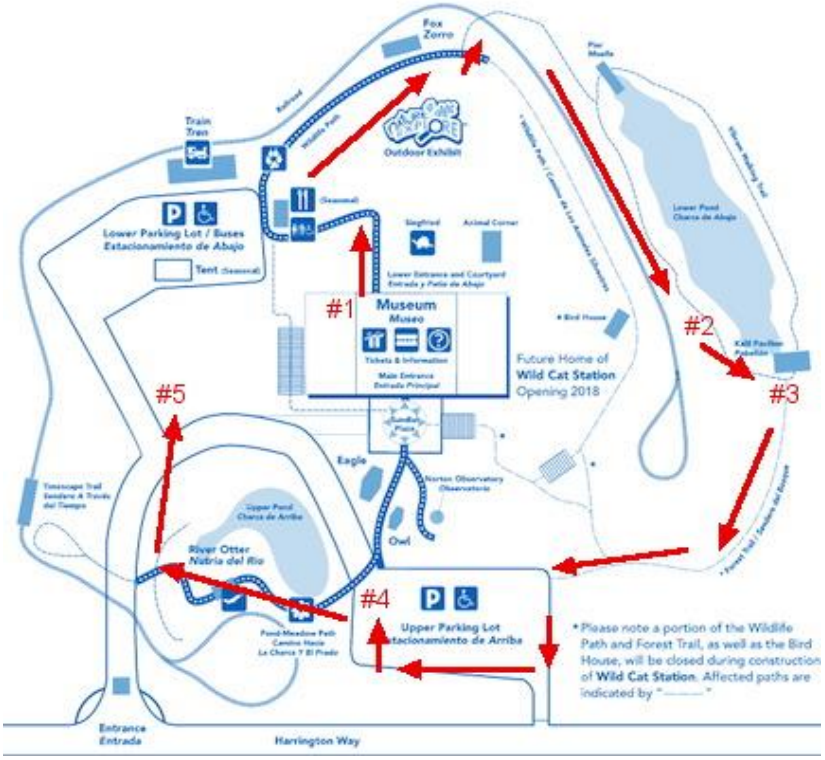



Activities shown top to bottom include glasses of water with rod to make sound;

balloon pump and balloon being blown up;

tuning folk with water molecules splashing out of bowl of water.

EcoTarium. The EcoTarium's post-show activity was implemented by the theater presenter. The 45-minute activity focused on the outdoor Sound Walk activity 7 in the YELL guide. The goal of this activity is to learn to listen actively to a soundscape, categorize sounds, and compare soundscapes from different locations. In a brief orientation in a classroom (#1 on map below), the presenter elicited examples of biophony, geophony and anthrophony, reviewed these terms, and explained the sound walk activity. Students then walked silently to an outdoor pond (follow the arrows from #1 on map). At the pond (#2 on map), the presenter indicated with a hand waving gesture that students should start listening. On a data sheet, students recorded surrounding sounds for 2.5 minutes, trying to keep a tally of every kind of sound and the sound category. During a debrief discussion (#3), students described sounds and sound categories that they heard, including biophony (birds, frogs), geophony (wind, water), and anthrophony (people, cars, train). Students then walked to a second outdoor pond (#4), where the presenter asked students to predict some differences from the previous site. Students then listened and recorded at the second pond. In the debrief period (#5), students again identified the categories of sounds, discussed differences with the first site, and predicted what might happen if they listened to the same location every day at the same time.




The students were very engaged in the listening and recording activities and participated enthusiastically in the discussions at each pond. However students were confused by the recording sheet directions of "list all sounds" and "tally every kind of sound;" for example, some students did not understand the method of 'tally' and some recorded every time a bird called or the wind blew versus tallying only different sounds (some examples of student recording sheets follow).

In a debriefing, the presenter noted that an example chart in the guide or an initial demonstration of how to fill out the chart would help data collection but that urban students might find it difficult to distinguish between the sounds of different birds, frogs, or other animals on a nature walk.

At each Site, list all of the sounds in your surroundings and put them in one of the categories below.

Keep a tally of every kind of sound you hear on your walk. Which sound did you hear the most?

| Site Name | Natural Sound | | | | Human-made Sound | |
|---|---|---|---|---|---|---|
| | Biophony | Tally | Geophony | Tally | Anthrophony | Tally |
| | e.g. Sound of a frog  | | e.g. Sound of rain  | | e.g. Sound of a car  | |
| Pond 1 | Birds<br>hoot<br>crickets<br>Frogs | \|\|\|\|<br>\|<br>\|\|\|\| \|\|<br>\|\|\|\| | wind | \|\|\|\|<br>\|\| | boat<br>train<br>People | \|\|<br>\|<br>\|\|\|\| |

| Site Name | Natural Sound | | | | Human-made Sound | |
|---|---|---|---|---|---|---|
| | Biophony | Tally | Geophony | Tally | Anthrophony | Tally |
| | e.g. Sound of a frog  | \|\|\|\|<br>\| | e.g. Sound of rain  | \|\|\| | e.g. Sound of a car  | \|\|\|\| |
| Pond 2<br>Parking Lot | birds<br>otter | | water<br>Rocks<br>wind | | Fountain<br>People<br>Talking<br>train<br>Car<br>Radio | |

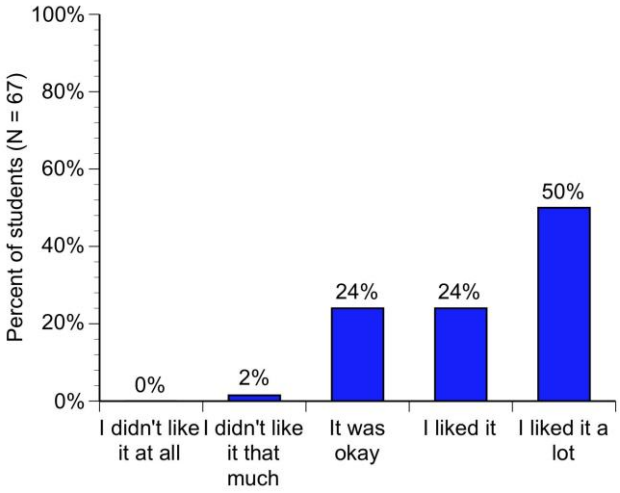
| Site Name | Natural Sound | | | | Human-made Sound | |
|---|---|---|---|---|---|---|
| | Biophony | Tally | Geophony | Tally | Anthrophony | Tally |
| | e.g. Sound of a frog  | | e.g. Sound of rain  | | e.g. Sound of a car  | |
| Pond #2 Parking lot | Cricket<br>grass<br>hopper | | water | | some one screaming<br>train | |

Drawing of EcoTarium sound walk activity by 5th grade boy.
A fox enclosure was passed during the walk.

### Appeal of the YELL activity

There were no significant site/grade differences or gender differences in quantitative ratings of activity appeal, so Figure 4 below presents results for the full sample of 67 students. Figure 4 indicates how much students liked their respective YELL activity: ***74% either liked their activity (24%) or liked their activity a lot (50%).***

Figure 4. Appeal of YELL activity




When asked what they liked about their activity, ***most Exploreum visitors reported liking all the physics of sound activities (41%) and many mentioned specific Labs: Lab A's balloon activity (21%), Lab C's tuning fork and water activity (21%), and Lab B's bottles/glasses activity (9%)***. For example:

*It was a lot of fun to make noises*
*It was so fun*
*I liked all 3 of the activities because of the different sound waves*
*I like that we got to do work with special equipment*
*I like the activities*
*I liked the way we made the balloon sound*
*How we tested the different sound waves on balloons*
*I liked the tuning fork and water experiment*
*I liked how we can see vibration in water with a tuning fork*
*I liked creating sound waves from a bottle*
*I liked that when we hit the stick on bottles that had different levels of water, and they were going high and low*

When asked what they did not like, ***91% of Exploreum students liked everything about the activities***. One student noted that *the balloon experiment was the least fun*; another did not like the bottles because *it wasn't much sound;* and a third student reported that *some of the stuff didn't work well.*

When EcoTarium students were asked what they liked about their activity, ***the majority reported that they liked listening to sounds of nature (52%). Another 18% noted enjoying the walk, and 21% liked seeing the fox and otter, animals whose enclosures were passed on the trail.*** **Three students (9%) liked doing research.** For example:

*I liked that we got to listen to the close sounds of nature*
*I liked listening to the sounds of the birds*
*I got to listen to nature. Birds, frogs, wind*
*I like it because I got to hear and see different things*
*I liked it because I heard lots of cool sounds*
*I liked that we got some exercise*
*I like the pond trail*
*I like the activity because got to walk around*
*Two things I liked was the fox, and otter*
*I like the part that we got to see a fox and otters on our trail*
*What I liked about it is that I got to see a new animal*
*I liked getting outside and doing our own research*
*I like the activity that we went outside and thinking about the sounds that we hear outside*

When asked what they did not like, ***61% of EcoTarium students liked everything about the Sound Walk. The remaining students (39%) voiced complaints about the physical part of the walk itself***; e.g., *we had to walk up the rocky hill; the hill; all the stumps in the path; it was tiring; many paths with pebbles which made it hard to walk.*

## Change in interest in program topics

On a four-point scale, students were asked to indicate how much their experience changed their interest in five soundscape related topics. There were no significant differences between site/grade and gender in the topic interest ratings, so Figure 5 shows all students who provided ratings: ***72% to 85% felt their interest increased "somewhat" or "a lot" in the soundscape topics.*** A majority of students reported that their experience with the theater show and YELL activity increased their interest "a lot" in the importance of soundscape ecology (64%), what soundscape ecology is (57%), methods and tools of soundscape ecology (55%), and how to understand spectrograms (55%). The students' science center experience was slightly less successful at increasing interest "a lot" in how to describe soundscapes (40% ).

Figure 5. Impact of science center experience on interest in soundscape topics (N = 67)

| How much did your experience today change your interest in each topic listed below? | Did not increase interest | Increased interest a little | Increased interest somewhat | Increased interest a lot |
|---|---|---|---|---|
| The importance of soundscape ecology (N = 61) | 7% | 8% | 21% | 64% |
| What soundscape ecology is (N = 65) | 11% | 12% | 20% | 57% |
| Methods and tools of soundscape ecology (N = 64) | 9% | 11% | 25% | 55% |
| How to understand spectrograms (N = 65) | 12% | 15% | 17% | 55% |
| How to describe soundscapes (N = 63) | 3% | 17% | 40% | 40% |

Increased interest across all program topics was significantly and highly correlated with appeal ratings of the theater show[7] and significantly but less highly correlated with appeal ratings of the YELL activity.[8]

[7] $r_s(58) = 0.53$, $p < 0.0001$. The Spearman rank-order correlation coefficient, $r_s$ , assesses the strength of association between two ranked variables, in this case "interest" and "appeal" ratings.

[8] $r_s(57) = 0.29$, $p = 0.02$

## FINDINGS: LEARNING

### Terminology

The *Global Soundscapes* experience introduced students to several new terms. **After their experience, a large majority of students were able to give correct examples of sounds in all three categories of biophony, geophony, and anthrophony. Students understood the term frequency much better than the term amplitude. Almost one-third of students could provide the scientists' definition of the soundscape as all sounds in a place.**

Biophony, geophony, anthrophony. The questionnaire asked for an example of each type of sound that students might hear in their own neighborhood. It was easiest to recall anthrophony with 95% of students providing a correct example, most often suggesting car sounds (58%) and people sounds (25%). Almost everyone (91%) provided a correct example of biophony, typically noting birds (67%). For Geophony, 80% could give a correct example, equally suggesting rain (29%) and wind (28%).

Students at the EcoTarium whose Sound Walk activity specifically reinforced these terms were significantly more likely to provide correct examples for the three sound categories (mean = 2.97 out of 3) compared with students at the Exploreum, although the latter group still showed high understanding (mean = 2.38).[9] There were no differences by gender.

Frequency, amplitude. Student understanding of the terms *frequency* and *amplitude* was assessed with three multiple choice questions, the results of which follow. Answers presented in the questions below are in the order of percentage responses, left to right, not in the order that they appeared in the questionnaire. Correct answers are underlined.

a. Larger animals produce sounds with a lower _____
frequency (59%) amplitude (32%) wavelength (6%) ultrasound (3%)

b. When vocal cords or rubber bands are tightened, the frequency of sound _____
goes higher (45%) varies both higher and lower (28%) goes lower (23%) does not change (3%)

c. Loudness of a sound depends upon _____
amplitude (18%) pitch (44%) frequency (23%) wavelength (15%)

For questions a and b, the number of students who chose the correct answer was significantly greater than expected, assuming that the four answers had an equal opportunity of being chosen. For question c, the number of students who chose the incorrect answer of pitch was significantly greater than expected.[10] Amplitude was not understood as equivalent to loudness.

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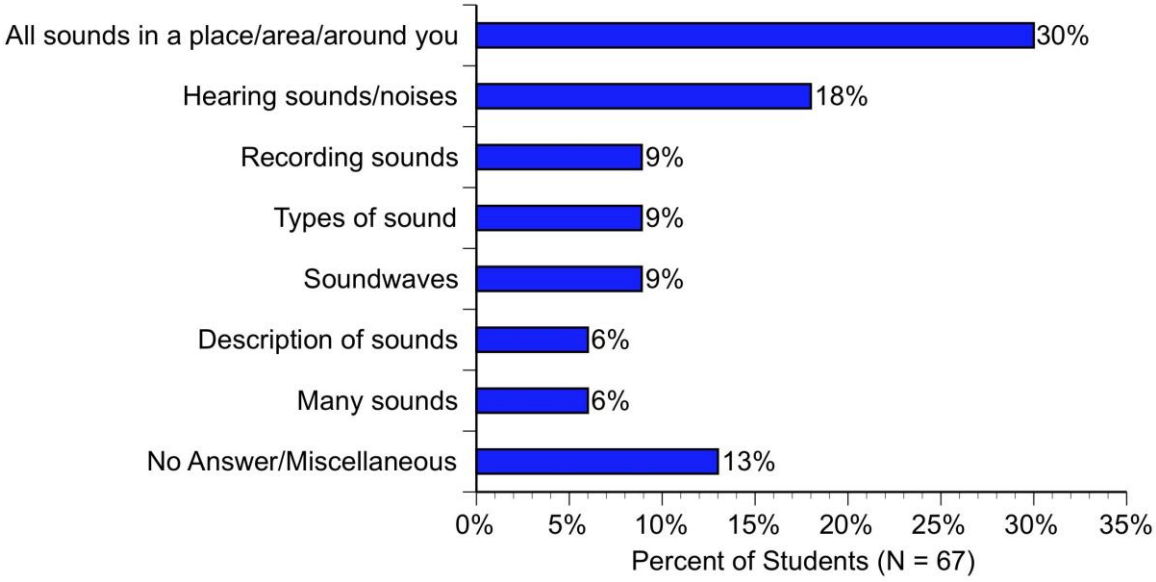
[9] $t$ (65) = 4.04, $p$ = 0.0001. $t$-tests are applied to two independent samples to assess the difference between means, in this case the mean correct responses of the two science center groups.

[10] For question a, one-sample chi-square test: $\chi^2(3, N=66) = 54.12$, $p < .0001$. For question b, $\chi^2(3, N=64) = 23.13$, $p < .0001$. For question c, $\chi^2(3, N=66) = 54.12$, $p < .0001$. One-sample chi-square test is used to test whether a categorical variable follows an expected population distribution.

Students at the Exploreum whose Sound Production activities reinforced the terms of frequency and amplitude were more likely to provide correct answers for the three questions (mean = 1.26 out of 3) compared with students at the EcoTarium (mean = 1.12), although the difference was not statistically significant. There were no differences by gender.

Soundscape. When asked to define what a soundscape is, students provided a wide range of responses, with 30% coming close to the scientists' definition of "all sounds in a place." Students at the EcoTarium, who experienced soundscapes during their Sound Walk activity, were significantly more likely than students at the Exploreum to provide the scientists' definition (42% at EcoTarium vs. 18% at Exploreum).[11] There were no differences by gender. Figure 6 presents the percent of students sorted into categories of their definition of soundscape. Example responses illustrating the categories appear below Figure 6.

Figure 6. Student definitions of soundscape




- 30% define soundscape as sounds of a place or area; for example:
  *A soundscape is a place that has sounds surrounding such place*
  *The sounds of a place or thing*
  *A soundscape is an ecosystem that has sound*
  *A soundscape is the sound of an ecosystem*
  *A soundscape is sounds in a certain area*
  *A soundscape is an area of sound*
  *An area with different types of sounds*
  *The sound of your surroundings*
  *It's the sounds of our surroundings*

[11] Two-tailed Fisher Exact test, $p = .03$. Fisher Exact Probability Test tests whether the two sites differ significantly in the proportion with which they gave the scientists' definition of soundscape or not.

- 18% defined a soundscape just as hearing sounds or noises with no mention or implication of a place; for example:
  *A soundscape is when you hear something like a bird singing*
  *A soundscape is what I heard*
  *A soundscape is when you hear different kinds of sounds*
  *When you hear different sound*
  *A soundscape is when you hearing noises*
  *A soundscape is when you hear different noises*
  *When hear different type of sounds*

- 9% focused on a soundscape as recording sounds; for example:
  *I think a soundscape is something to use to track and record a sound*
  *A soundscape is what records any sound someone or something makes*
  *Where scientists set boxes or recorders around many places*
  *Those things where you record animal sounds*
  *Sounds you recorded*

- 9% listed types of sound in a soundscape; for example:
  *Animals, weather, sound of cars*
  *A soundscape is all the noises of nature*
  *Soundscape is something, someone or animal makes and you figure it out*
  *Many types of sounds that living things make*

- 9% defined soundscape as soundwaves; for example:
  *A soundscape is like soundwaves*
  *A soundscape is soundwaves*
  *A soundscape is like the different waves*

- 6% noted terms to describe sounds for example:
  *A high or low pitch sound*
  *The frequency or wave length*

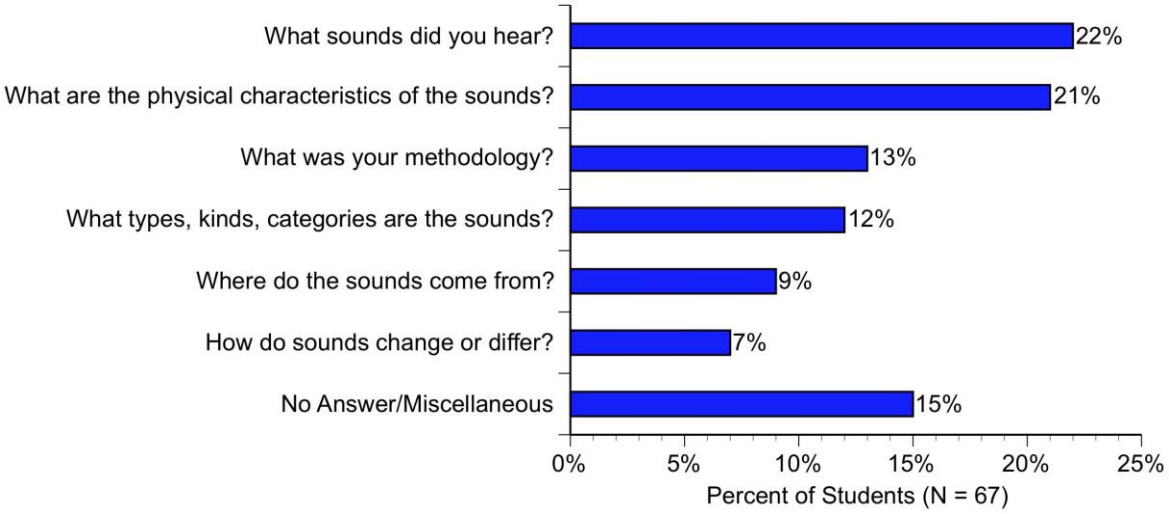
- 6% simply defined soundscape as many sounds; for example:
  *A variety of sounds*
  *A soundscape is a bunch of sounds*

- 13% could not define soundscape or gave answers that do not fit into the above categories; for example:
  *It is when you have noise and difference*
  *Something that has to do with sound*
  *It means to listen with your ears*

## Analytical approaches

In analyzing soundscapes, ecologists look for categories of sound, sound frequencies and amplitudes, changes over time, and differences by location. To examine student understanding of analytical approaches presented in their *Global Soundscapes* experience, the questionnaire asked students to suggest one question that a soundscape ecologist might ask about soundscapes that the students imagined recording several times in different places around their neighborhood. **The most common questions were about identification of sounds (22%) and about physical characteristics of the sounds (21%) rather than the more complex analytical questions of changes or differences (7%).** Figure 7 presents the percent of students sorted into categories of analytical questions. Example responses illustrating the categories appear below Figure 7.

Figure 7. Categories of questions a soundscape ecologist might ask about students' neighborhood soundscape recordings




- 22% provided a simple identification question such as <u>what did you hear</u>. Students at the EcoTarium who experienced the Sound Walk activity, during which data recording and discussions focused on what was heard, fell more frequently into this category than students at the Exploreum (33% vs. 12%, respectively).[12] Example questions in this category follow:
  *What did you hear?*
  *He/she might ask about what am hearing?*
  *What animal did you hear?*
  *What animal is that?*
  *What animals have you heard?*
  *He might ask what is that sound?*
  *What was that noise?*

[12] Two-tailed Fisher Exact test, $p = .04$

- 21% asked a question about the sounds' physical characteristics. Students at the Exploreum, who experienced Sound Production activities focused on sound physics, fell more frequently into this category than students at the EcoTarium (32% vs. 9%, respectively).[13] Example questions in this category follow:
  *How* [many] *high or low frequencies are made?*
  *Is it a low or high soundscape?*
  *Which one is lower and higher?*
  *What pitch does the birds have every day?*
  *How fast does sound waves really go?*
  *How fast does soundscapes go?*
  *How loud it is?*

- 13% focused on methodology; for example:
  *What tools did you use?*
  *What things helped you record and study these sounds?*
  *They might ask how you do this?*
  *When would you stop and look at a different place?*
  *What was the date?*

- 12% asked about sound type, kind, or category; for example:
  *What kind of sounds do you record?*
  *What kind of sounds do you hear?*
  *They might ask you what type of sound is this?*
  *What types of sounds did you hear?*
  *What are the Biphony, Geophony, and Anthrophony sounds?*

- 9% queried about location; for example:
  *Where is this from?*
  *Where is all the sound coming from?*
  *Where did you record at?*
  *Where did you go and get the sound from?*
  *Where was it recorded from?*

- 7% addressed differences or changes in the soundscapes; for example:
  *They might ask how did the sound change?*
  *Why do they sound the same and different?*
  *What is the difference between the sounds?*
  *Were the sounds different in each location?*

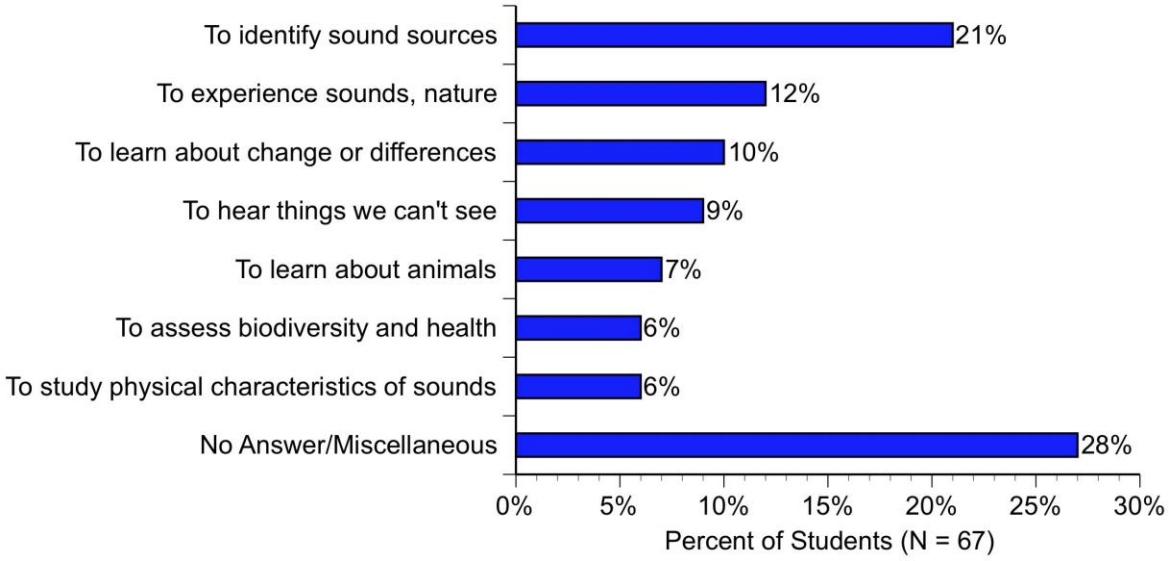
- 15% gave no answer or wrote questions that do not fit into the above categories; for example:
  *What kind of sound do you find interesting?*
  *Why are there so many birds?*
  *Why do animals make sounds like that?*

[13] Two-tailed Fisher Exact test, $p = .03$

### Importance of soundscapes

Students were also asked why it is important to collect and study soundscapes. **Students most commonly felt that studying soundscapes is important to identify sound sources (21%) and to experience sounds and/or nature (12%).** A good portion (28%) of the students gave miscellaneous responses that did not address the question as it was intended. Figure 8 presents the percent of students sorted into categories, and example responses illustrating the categories appear below Figure 8.

Figure 8. Reasons why it is important to collect and study soundscapes




- 21% felt soundscapes were important <u>to identify sound sources</u>; for example:
  *So ecologists know what noise that ecosystem produces*
  *It is important so you know what sounds ecosystems make*
  *It's important to collect and study soundscapes so you can know what is making the sounds*
  *It is important because then when you hear something you know what it is*
  *It is important to collect and study soundscapes because one day you hear something and you wonder what it is*
  *It is important to collect and study soundscapes because you can hear sounds you never heard before*

- 12% thought soundscapes were important <u>to experience sounds and/or nature</u>; for example:
  *Why I think it is important to collect and study soundscapes is to experience the sounds*
  *It is important because there are lots of things to experience outdoors*
  *I think it's important because I can listen to Nature*
  *So you can learn more about nature*

- 10% deemed soundscapes important to learn about change or differences; for example:
  *What's different about each soundscape in each place*
  *We can determine how the animals sound right now and how are their future*
  *To tell the difference how things change over the years*
  *To know what happens to this place*

- 9% recalled from the show that soundscapes are important because you can hear things that you can't see; for example:
  *To know things your eyes can't know*
  *So you know what's going on and sometimes your eyes don't tell you everything*
  *I think it is important because it helps us learn about things we may not see*
  *It is important because you need to listen in case an animal is out there*

- 7% felt that soundscapes are important to learn about animals; for example:
  *To find out about animal's lives or their mating song*
  *You'll never know what sound an animal makes*
  *I think it's important because you might want to know your surroundings of animals*

- 6% suggested that soundscapes are important to assess biodiversity and health; for example:
  *It is important to study soundscapes because you need to know what's in that area and if you don't hear an animal that you used to hear it probably went away or becoming extinct.*
  *What I think is important to collect and study about it are the species*
  *So you can discover new animals and species that might be important*

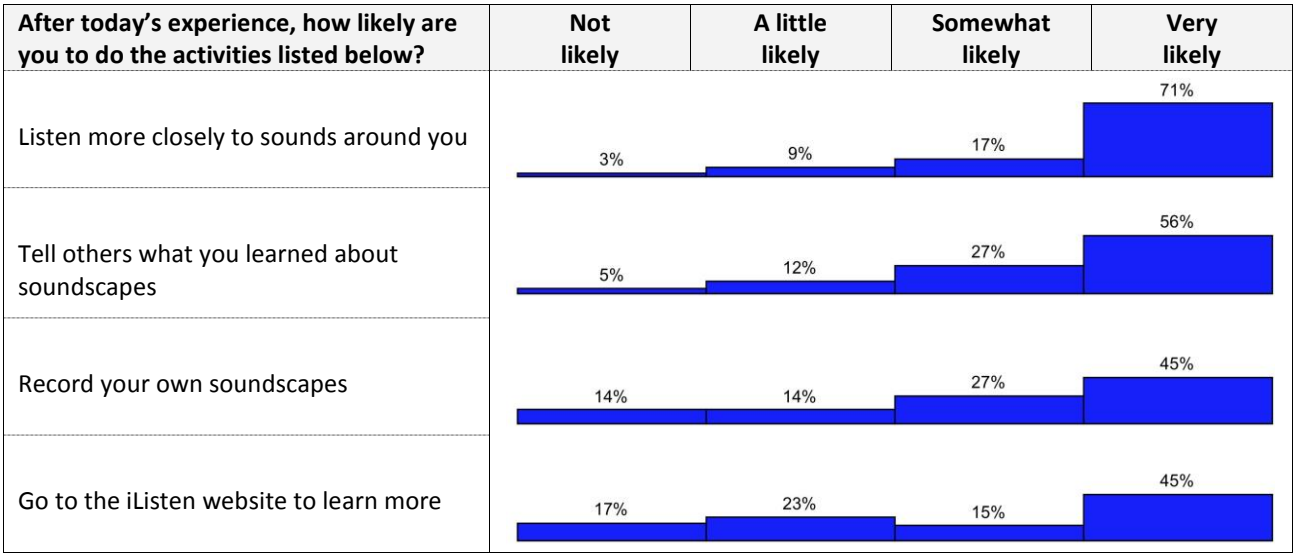
- 6% thought that soundscapes are important to study physical characteristics of sound; for example:
  *I think it is important because if you want to know how high or how low then you will know by recording it.*
  *To study high and low frequencies*
  *To figure out the soundwaves*

- 28% provided no answer or miscellaneous answers that did not address the question as intended; for example:
  *So if you get lost you could hear the sounds and find your way*
  *So you know that your careful and don't walk into a bear yelling loudly*
  *Just in case we want to be a scientist*
  *What you heard was the most important part*
  *I think the important thing is the Sound Scapes itself*
  *I think the sound is important*
  *it is important so you will know for very helpful and important reasons*
  *It's just something to know*
  *Cause we use sound everyday*

## FINDINGS: FUTURE BEHAVIOR

On a four-point scale, students rated how likely they were to do four activities after their experience at the science center. There were no significant differences between site/grade and gender in the topic interest ratings, so Figure 9 shows 66 students: ***60% to 88% thought they were "very" or "somewhat" likely to do four different soundscape-related activities after their experience.*** A majority of students reported that their experience with the theater show and YELL activity made them feel "very likely" to listen more closely to sounds around them (71%) and to tell others what they learned about soundscapes (56%). Just under half of students (45%) felt they were "very likely" to record their own soundscapes or go to the iListen website to learn more.

Figure 9. Impact of science center experience on future behavior (N = 66)




Likelihood to do these soundscape-related activities was significantly and highly correlated with appeal ratings of the theater show[14] and significantly but less highly correlated with appeal ratings of the YELL activity.[15]

[14] $r_s(64) = 0.56$, $p < 0.0001$

[15] $r_s(63) = 0.38$, $p = 0.002$

## DISCUSSION

**The *Global Soundscapes* interactive theater show was very effective in engaging and appealing to fifth and sixth grade low income minority students.** In rating the theater show itself, 85% of students either liked it or liked it a lot. By integrating a live educator into presentation of the film, this program is unique in the world of giant screen films and its appeal is very competitive with traditional giant screen films. Looking at quantitative appeal results from student summative evaluations of 11 NSF-supported giant screen films, we note that students in this evaluation rated *Global Soundscapes* higher in appeal than students viewing 9 of the 11 other STEM films. The theater show audience most liked learning new information about sound, hearing different sounds, and the audience interactivity.

**Three-quarters of the participating students in the summative evaluation liked or liked a lot their post-show YELL activity.** Students at the Gulf Coast Exploreum were highly engaged with the physics of sound activities, and students at the EcoTarium enjoyed listening to sounds of nature and walking the trail.

**A majority of students reported that their experience with both the theater show and the post-show activities increased their interest "a lot" or "somewhat" in the importance of soundscape ecology, methods and tools of soundscape ecology, how to describe soundscapes, what soundscape ecology is, and how to understand spectrograms.**

**Exposure to the theater show and post-activities increased knowledge of sound and soundscape fundamentals, but the experiences were somewhat less effective in communicating approaches to analyze soundscapes and the importance of soundscape ecology.** A majority of students understood the meaning of the terms of anthrophony, biophony, geophony, and frequency but were less able to understand that the term amplitude applies to loudness and less able to provide the scientists' definition of soundscape as all sounds in a place. Post-show activities added value to the show, as those students whose activities reinforced specific terms were better able to respond to questions about such terms. To analyze soundscapes, most students suggested that ecologists identify sounds or establish physical characteristics of the sounds but very few students mentioned applying more complex analytical approaches of looking for changes over time or differences by location. From their experiences, students most commonly concluded that soundscapes are important to identify sounds or to experience sounds and/or nature; whereas very few students acquired the project's intended knowledge outcome that studying soundscapes is important to assess health of an ecosystem.

**The theater show and YELL labs effectively encouraged students to express an interest in doing follow-up soundscape-related activities.** After their experience, a large majority of students felt they were likely to listen more closely to sounds about them, to tell others what they learned about soundscapes, to record their own soundscapes, and to go to the iListen website to learn more.

**In conclusion, the science center staff successfully implemented the *Global Soundscapes* theater show and post-show YELL activities with an audience of low income minority youth to achieve the project's planned outcomes of engagement, appeal, interest, knowledge, and future behavior.**

APPENDIX

Note to report readers: The post-experience questions are presented below but the space for open-ended answers is not. With space, the questionnaire is a full two pages. To avoid a response order effect, an alternative questionnaire was answered by half of the students with the response choice order reversed.

**Your feedback about your experience today will help us improve the theater show and activities.**

1. Are you in θ 5th grade θ 6th grade
2. Are you a θ boy θ girl
3. Check a box that shows how much you liked the theater show today.

o I didn't like it at all o I didn't like it that much o It was okay o I liked it o I liked it a lot

4. What did you like about the theater show?
5. What did you not like about the theater show?
6. Thinking about sounds that you hear in your own neighborhood, give an example of a

   Biophony sound: _____

   Geophony sound: _____

   Anthrophony sound: _____
7. Check a box that shows how much you liked the activity after the theater show.

o I didn't like it at all o I didn't like it that much o It was okay o I liked it o I liked it a lot

8. What did you like about the activity after the theater show?
9. What did you not like about the activity after the theater show?
10. Imagine that you record soundscapes several times in different places around your neighborhood. What question might a soundscape ecologist ask about your soundscapes?
11. As best you can, define what a soundscape is:
12. Why do you think it is important to collect and study soundscapes?
13. How much did your experience today change your interest in each topic listed below?

| | Did **not** increase interest | Increased interest **a little** | Increased interest **somewhat** | Increased interest **a lot** |
|---|---|---|---|---|
| What soundscape ecology is | o | o | o | o |
| Methods and tools of soundscape ecology | o | o | o | o |
| The importance of soundscape ecology | o | o | o | o |
| How to describe soundscapes | o | o | o | o |

| | | | | |
|---|---|---|---|---|
| How to understand spectrograms | o | o | o | o |

**Check a box for the word or words that you think best complete the sentences below:**

14. Larger animals produce sounds with a lower _____

o amplitude o frequency o ultrasound o wavelength

15. Loudness of a sound depends upon _____

o wavelength o frequency o amplitude o pitch

16. When vocal cords or rubber bands are tightened, the frequency of sound _____

o goes higher o does not change o goes lower o varies both higher and lower

17. After today's experience, how likely are you to do the activities listed below?

| | **Very** likely | **Somewhat** likely | **A little** likely | **Not** likely |
|---|---|---|---|---|
| Tell others what you learned about soundscapes | o | o | o | o |
| Record your own soundscape | o | o | o | o |
| Listen more closely to sounds around you | o | o | o | o |
| Go to the iListen website to learn more | o | o | o | o |

18. Write below or on the back any other feedback you have about your experience today: