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Session 2aED: Education in Acoustics

2aED6. Development of educational stations for Acoustical Society of America outreach

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One of ASA's outreach activities is hands-on exploration workshops for local school groups and girl scouts troops held during our semiannual conferences. In general, outreach programs have three main purposes: 1) public service, 2) generate enthusiasm and interest, and 3) supplement learning. Despite the good work that has been done in the past, it is apparent that the goals of the current ASA outreach activities could be better achieved through increased efficiency. This project continues the development of the ASA outreach programs held in conjunction with our meetings to better meet the above goals. Specifically, we have developed a structure in which demonstrations are grouped into five-minute stations each pertaining to a different physical system. To increase the ease with which volunteers can assist with the stations, one-page summaries and reference posters outlining the basic principals of each station have been prepared. Volunteers are encouraged to be guided by the interests of the students in their interactive discussions.. In addition, we have created a brief introductory presentation for the workshops to explain what can be done in the field of acoustics. These improvements not only provide opportunities to excite student interest but also increase the efficacy of the outreach efforts.

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INTRODUCTION

Science outreach programs can play a valuable role in shaping attitudes and future educational goals when they capture and build upon the interest of participants. A traditional difficulty, however, has been the development of outreach programs that can efficiently train[1] facilitators to interact meaningfully with participants and also reach a sufficient diverse audience[2] in order to promote learning. The Acoustical Society of America (ASA) has a history of conducting outreach workshops for secondary education in conjunction with its semiannual conferences. These sessions began in 1987 thanks to the efforts of Uwe Hansen and others in the Education in Acoustics committee. In 2008, Marcia Isakson and Tracianne Neilsen started a similar outreach session for the Girl Scouts of America as an initiative for the Women in Acoustics committee. Many ASA members have volunteered their time to make these events successful. The goals of these outreach activities are to provide a public service, generate enthusiasm, build awareness and supplement learning. To build upon the foundations built with these past programs, the structure of these outreach workshops has recently undergone changes to address some concerns and advance the goals of the outreach sessions through stronger pedagogical techniques and increased efficiency.

Figure 1. Left: ASA student member volunteers and Girl Scouts at 167th meeting of ASA in San Diego, CA. Right: Dr. Traci Neilsen demonstrating the Chaldni plate.

The goal to develop a unified structure of the ASA outreach workshops and to provide the opportunity for participants to leave with a better understanding and appreciation for a Science, Technology, Engineering, and Mathematics (STEM)-related field, has been advanced on several fronts. First, a brief introductory presentation for the sessions has been made to generate excitement, give examples of what can be done in the field of acoustics, and get the students engaged with the material so that they could gain the most out of the experience. This supports the pedagogical argument[3] that in order to shift to learner-centered teaching, the students must understand their role and be empowered to accomplish it.

Second, the demonstrations have been grouped into five-minute, hands-on stations each pertaining to a different physical system. A similar format[4] has previously proven to be highly effective in increasing the efficacy of outreach efforts in other outreach programs. Each station has a specific learning outcome based on a real-world acoustical application. How we hear and how string instruments work are examples of the 13 main physical systems explored in these stations. The hands-on stations become an opportunity for a learner-centered environment when an inquiry-based[5] format is used. With this intended standard, the students will be guided to personally engage with the material and gain an appreciation of how the science of sound influences their daily experiences. In addition, creating a consistent structure for the hands-on portion of the session is key in increasing efficiency of the management and production of the outreach sessions.

Figure 2. ASA member assisting local students at 166th meeting of ASA.

Third, to increase the ease with which volunteers can assist with the stations, one-page summaries and reference posters have been developed that outline the basic principles to be explored at each station. A concern that had been raised was that many of the volunteers are hesitant to help because of a lack of understanding of what is expected of them. They often do not feel prepared to give an impromptu lecture. However, as traditional lecture methods of teaching have been shown to be one of the least effective[6] methods in learning physical principles, the prepared station outlines assist volunteers to more easily understand their expectations. The written outlines also provide volunteers with a guide on how to troubleshoot the equipment used in the hands-on demonstrations and to understand clearly their roles in guiding the children through inquiry based learning.

Figure 3. ASA member and local student at 166th meeting of ASA exploring body resonances of string instruments.

The preliminary results of these efforts are presented in this paper. A further description of the introductory video and the hands-on stations are given. Examples are included of the station outlines provided for volunteers. The first implementation of the revised outreach workshops took place at the 166th meeting of ASA in San Francisco in December 2013. The initial reactions of the students and members as well as recommendations for future improvements are discussed.

RESULTS

Our plan was to increase the efficacy of the ASA outreach activities through pedagogy, the stations used, and more efficiently utilizing volunteers. The modifications have not only provided more structure and order to the program, but they have increase the value of the outreach efforts. Applying concepts of active learning from physics education research, we have created an introductory presentation, provided volunteers guidance on how to interact with students and given volunteers an inquiry-based structure all built on active learning principles in science education.

The introductory presentation involves both a short thought provoking video and a few slides explaining the expectation for the students. The five and a half minute video "Amazing Acoustics" (https://www.youtube.com/watch?v=IGfAL8KgHMc) is designed to get participants thinking about what the science of sound is and connecting it with their daily lives. The short presentation that follows the video explains how the students will proceed through the session exploring acoustics with the help of professionals at the different stations. This helps them understand their role in the learning process and establish order during the sessions.

It was important to clearly explain to the volunteers what they would be expected to do. We made clear that we wanted them assisting students through question-driven exploration of basic acoustics principles, such as how string instruments create sound, and that they would receive materials to prepare them properly. We also held a short training before the students arrived. This helped volunteers understand the format and give them time to familiarize themselves with the materials provided for them at each of the different stations and answer any further questions they had. Volunteers were enthusiastic and very helpful once they understood the purpose of the outreach sessions and gained an idea of what it would entail.

One of the key materials provided to volunteers was a one-page laminated summary for the stations. This outline and the brief training gave the volunteers all the tools they needed to help guide participants through the learning process. The outlines contain a picture of the station setup, a list of equipment that was provided, a question bank and a reminder of the volunteers' basic purpose. The list of questions are effective examples for inviting participants to think more critically about sound and therefore learn the principles governing the physical systems. These questions are not meant to be a complete list, but rather to help volunteers understand the types of questions that could be useful in gauging what participants already know about the physical system they were exploring, and then to help them think more deeply than they previously have about the system. A couple examples are given in Figure 7 and 8 at the end of the article. Each summary has a reminder that simply says, "*Engage audience for approximately 5 minutes by exploring the topic together by asking questions and allowing the participants' interests to direct the focus.*" This reminder served the purpose to explain once again to volunteers that they are not there to lecture. It helps to remember that a volunteer is a guide for the participants personal learning and to focus on participants' specific personal interests that relate to each system and to answer questions in an interactive way.

Guided by the concepts of active learning, we developed hands-on stations tied to 13 different physical systems. This involved first determining which physical systems we would focus on. Second, we took

Figure 4. Hearing Loss station with banner and equipment at 166th meeting of ASA.

inventory of what demonstration equipment ASA possessed and gathered new equipment to better help each demo tie back to the specific physical principles and learning outcomes. The selection of physical systems was guided by what equipment ASA currently had as well as through experience from BYU's acoustics outreach and BYU's introduction to descriptive acoustics class. Then we organized the equipment by station in protective pelican cases to be ready for transport to and from ASA outreach events. In addition, we labeled each item as belonging to the Acoustical Society of America's outreach efforts as well as with which specific station it belonged to in order to keep equipment more organized.

Since participants are more likely to engage and remember "real things," or what they can relate to, the stations we developed are focused on common real-life physical systems. The stations we developed deal with 13 common physical systems, such as loudspeakers and a variety of musical instruments. To clarify, there are 13 main topics, but several of them have more than one demonstration and can thus be divided into multiple tables when the number of volunteers exceeds 13. In addition, members of ASA are welcome to bring and share their own demonstrations. A list of each station and the equipment used is summarized in Table 1 at the end of the article. Each station, as mentioned, has a corresponding outline. A couple examples are shown in the following figures. The combination of the real-world applications of acoustic principles, interesting demonstrations with updated equipment, and the outlines provided to the volunteers, adds to the order of the stations and focuses them on specific learning outcomes.

Figure 5. Standing Waves station banner and setup at 166th meeting of ASA.

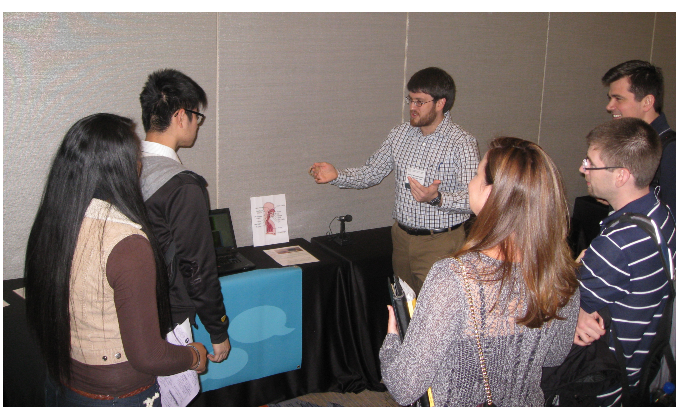

Figure 6. An ASA student member prepared to guide students in learning about the speech production system at the 166th meeting of ASA during the school demonstrations in acoustics session.

As previously mentioned, measures have been taken to seek to build the efficiency of the outreach sessions and increase the ease with which volunteers could assist. Clear explanations, outlines, and organization have all been a part of this. We have also purchased 4 ft. x 2 ft. vinyl banners seen in Figure 3, 4, & 5 with the title and a simple logo for each station to illustrate to participants what they are about to explore. The banners, along with the video introduction help prep the participants for learning. These banners also add to the professional look of each of the stations.

Another important aspect of preparing the students to learn is the introduction of the volunteers following the introductory presentation. This helps participants understand who the volunteers are and initiate a relationship of trust with these professionals in acoustics. This also helps build participants' excitement knowing a little about the specific area of acoustics each volunteer is working in. With this, we believe volunteers will have more confidence and the participants can know who to ask more specific questions they may have regarding acoustics.

We also worked toward the general efficacy of both outreach sessions by uniting them together in a more streamlined program. To accomplish this, all parties involved in running each of the sessions met and collaborated plans, equipment, and efforts which helped to unite all our goals and accomplishments in improving the outreach sessions for the Acoustical Society of America. We combined all the equipment owned by the Acoustical Society of America, which was gathered from different locations and then organized as previously mentioned. We agreed to use the same general format, equipment, and even schedule sessions on the same day and in the same room. All parties recognized that by doing so we would ease the management of the outreach sessions for all involved in the future.

CONCLUSION

The initial reactions of students and of ASA member volunteers have been very positive. The students who attended the 166^{th} ASA meeting were from local high school physics classes. Some students who previously thought physics was boring and uninteresting expressed their newfound enjoyment and excitement for physics, especially emphasizing in acoustics, by the end of the outreach session. Other students made connections with professionals to receive information regarding and potentially funding for higher education. Students generally expressed appreciation and enjoyment for the opportunity to learn about sound and be able to understand their world better through their increased understanding of sound related to the 13 physical systems. The member volunteers who had participated in previous school outreach sessions expressed great appreciation for all that had been accomplished to improve upon the stations and the organization. Other members who had not previously participated were impressed by the success they saw the session could have in bringing STEM enthusiasm to local youth. Regarding session organization and coordination, unifying the content of the two ASA outreach sessions reduces the setup and takedown time. It also further limits possibilities for equipment to be lost and ease the workload of planning and carrying out the sessions by allowing the work to be shared and utilizing the same format.

While much has been accomplished towards the main goals, the outreach sessions are still works in progress. In the future, new demonstrations can be added, current demonstrations can be refined and other acoustical systems or processes could be emphasized to further improve future outreach sessions. Current outlines and more information about the current state of the outreach efforts can be obtained by emailing the authors. The gathering, organization and preparing of volunteers also has room to be improved upon. We hope that there will be continued improvements to the outreach sessions to keep the efficacy of the program. We also hope that the continuation of this program through future ASA members will be eased by our efforts.

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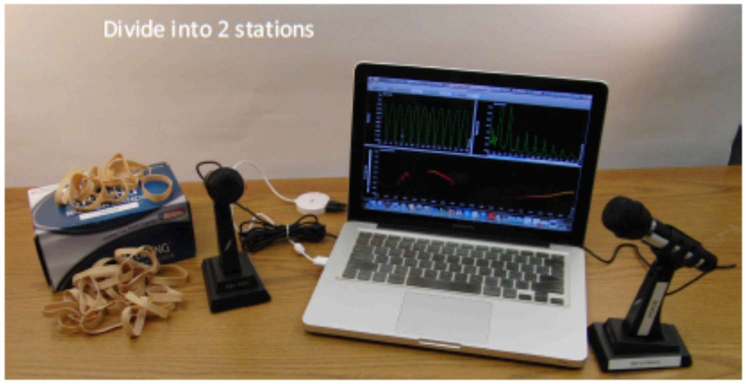
Figure 7. Speech station presenter outline used at the 166th meeting of ASA in the school demonstrations in acoustics session.

Speech



Equipment:

Rubber bands

Laptop with waveform viewer and spectrogram

Stroboscope video clip

Oscilloscope/ spectrogram

Microphone

Diagram of human noise production system

Engage audience for approx. 5 min. by exploring the topic together by asking questions and allowing the participants' interests to direct the focus.

Station 1: Vocal folds

What's the process for making speech sounds? *Show diagram of speech anatomy and talk about the parts.*

What do the vocal folds do? *Feel vibrations of Adam's apple for voiced speech sounds and lack of vibrations for unvoiced sounds*

How do the vocal folds make different pitches/frequencies? *Demonstrate the change in plucking frequency on a rubber band for changes in tension and mass per unit length with the rubber bands (give one to each participant) and relate these to the mass-spring systems in the Resonance station.*

Station 2: Vocal Tract

Explain that the vocal folds generate the sound but changing the vocal tract is what makes the different speech sounds.

What is your vocal tract? What are you doing with it when you make the different vowels? *Have them try it.*

Look at speech waveforms and spectrograms of vowels and other phonemes. What is the same and different?

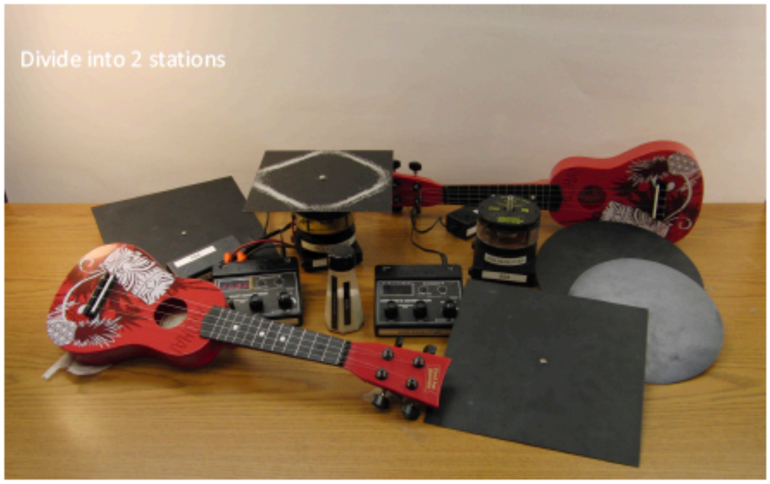
Do you know anyone who reads lips? How does that work? Is it ever confusing? *Try "marry" and "bury"*

Figure 8. Violin & Guitar station presenter outline used at the 166th meeting of ASA in the school demonstrations in acoustics session.

Violin/ Guitar

Equipment:

- Pasco Shaker (x2)
- Sine wave generator (x2)
- Chaldni plate (x5)
- Sand
- Slide guitar(x2)
- Ukulele (x2)
- Stereo banana connector



Engage audience for approx. 5 min. by exploring the topic together by asking questions and allowing the participants' interests to direct the focus.

Station 1: Ukulele

Does anyone know how to play a string instrument? How do they work?

What is the difference between the sound produced when a string instrument is bowed vs. plucked?

How do you play different notes on a string instrument? *Demonstrate with ukulele.*

What are different ways are to change the pitch being played by a string instrument?

How do you tune a string instrument? *Demonstrate with ukulele.*

How does the body of the instrument affect the sound? *Resonances of the body change the sound.*

Station 2: Chladni plates

Use chaldni plate to show how the body of a string instrument has multiple natural frequencies/resonances.

Explain that the salt falls into the nodal lines – places that aren't moving, like they saw with the standing waves on the slinkies.

Table 1. List of stations, demonstrations used, and short explanations of how to use each

Station Title	Demonstration	General Physics Concepts
Standing Waves	Long thin spring	Making standing waves.
	Small Slinkies	
	Pasco driver & sine wave generator	
Resonances	Mass-spring set	Show difference in natural frequency for various mass-spring combinations.
	Ames tube w/ tuning forks	Show difference in sound generation of tuning fork and Ames tube.
	Crystal glasses	Excite resonances in objects.
	Glass bottles	Show difference in resonance due to volume and neck.
Reflections	Ripple Tank	View wave interaction.
Echolocation	Laser Pointer & mirror	Observe angle of incidence and reflection.
	Hypersonic Speaker	Listen to sound reflections. Example of echolocation.
	Illustrations of bats/dolphins/ SONAR/RADAR	Show real-world connections.
Voice	Box of Rubber Bands	Illustrate changes in the vocal folds responsible for the fundamental frequency of the voice.
	Laptop w/ Oscilloscope/Spectrogram/microphone	View waveform associated with differenct speech sounds. Vowels are periodic and fricatives are nonperiodic.View fundamentals and formants associated with different speech.
	Diagram of human noise production system	Illustrate the parts of the voice production system.
Hearing	Illustrations of anatomy of the ear	Illustrate the parts of the ear.
	A few short boomwackers	Hear difference between open/closed tube.

	Laptop that can play YouTube video of the basilar membrane	Show how the basilar membrane responds to different frequencies.
Hearing loss	Laptop/NASA Auditory demo DVD	Illustrate average hearing loss with age.
	Sound level meters	Quantify loudness and connect what is too loud to real life experiences.
	Ear plugs	Show how to properly wear hearing protection.
Noise Control	Bose noise cancelling headphones	Demonstrate the benefits of noise cancellation.
	Music box demo	Demonstrate the what transmits vibrations and what absorbs.
Piano/Dulcimer	Backpack Hammered Dulcimer	Show relationship of string length and pitch.
	Spectrum analyser	Show how hard hammers have a brighter sound than soft hammers.
Violin/Guitar	Slide Guitars	Demonstrate how tension effects pitch and show how instrument bodies resonate.
	Ukulele	
	Chladni Plates	
Wind/Brass Instruments	Boomwackers	Illustrate the resonance due to length of pipes.
	Recorders	Apply the concept of resonance changes due to length of a pipe with instruments.
Electronic Music	Theremin	Have participants make electronic music.
	Laptop w/ Audacity or garage band and Oscilloscope/spectro gram	Show how electronic music works and how versatile it can be.
Loudspeakers	Surface mount vibration speaker	Explore what materials transfer good vibrations into acoustic signals.
	Loudspeaker in box demo	Show the effect of a baffle on a speaker.
	Illustration of loudspeaker cutaway	View the components of a loudspeaker.