Didgeridata

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2019-04-19

Contents

Introduction

This activity guides groups of students through a brief study of the history and construction of either a didgeridoo, the world's oldest wind instrument, or a paixiao, a chinese pan flute. Students will work with polyvinyl chloride (PVC) pipe and PVC-cutting tools to design and create a playable musical instrument which will be used by students to compose a custom song related to climate data such as atmospheric CO_2 concentration or global temperature anomalies. In this way, the sonification of climate data will be accomplished with a student musical chorus. The activity will conclude with a group jam session with participants invited to provide percussion for the wind section. An attempt will be made to have expert musicians join the program via teleconference as a guest speaker to provide instruction and background information.

Chapter 1

Learning Goals and Success

The learning goals for this activity are for students to:

- Develop an awareness of the science and history of the didgeridoo and the paixiao
- Practice hands-on construction methods to create custom, playable PVC musical instruments
- Develop an awareness of long-term trends in climate data
- Create a collaborative musical piece inspired by climate data
- Perform the custom musical piece using the didgeridoo and/or the paixiao

Success will be determined by:

- Creation of playable PVC musical instruments
- Creation and performance of a musical piece inspired directly by trends in global climate data

Figure 1.1: Didgeridoo.

Chapter 2

Didgeridoo

2.1 Overview

The theme of 2019 MIT STEAM Camp is wind and perhaps an exploration of climate data and wind instruments can faithfully incorporate the theme as well as help inform the public about information to which they may not have been exposed. This chapter describes a bit about the didgeridoo, a wind instrument of great significance, and presents instruction for construction of a DIY version that can be created inexpensively and with a high degree of customization.

2.2 History and Significance

The didgeridoo, or yidaki, is an ancient wind instrument believed to have originated among the indigenous people of northern Australia over 40,000 years ago (Harris 2013). This instrument is traditionally used for cermonial functions and also for recreational and entertainment purposes. Ramin Yazdanpanah is a modern didgeridoo musician who plays with the Maharajah Flamenco Trio, a group that incorporates global sounds into their music.

2.3 Science

Hopkin (2005) sums up an article by Tarnopolsky et al. (2005) and notes that skilled didgeridoo musicians can adjust their throat anatomy to produce a very wide range of timbres. Fletcher (1996) provides a summary of the physics of this simple instrument.

2.4 Construction

The didgeridoo will be constructed from three PVC components seen in Figure 2.2: a reducing coupling (A), a pipe (B) , and a trap adapter (C and D). The length (L) of the pipe is variable and determines the key of the instrument. The mouthpiece is in two pieces. Part D will need to be threaded onto Part C. All other fittings should be pressed on until secure. No adhesives are used in this construction.

To begin, join the reducing coupling (A) to the pipe (B).

Next, join the pipe (B) to the trap adapter base (C).

Finally, join the trap adapter base (C) to the trap adapter nut (D) by carefully threading the nut onto the base.

Your PVC didgeridoo should now be fully assembled. Wipe down the trap adapter with an alcohol pad before attempting to play!

Figure 2.1: Ramin Yazdanpanah of the Maharajah Flamenco Trio from the official video for "Dariya." Roughcut Productions, 2017.

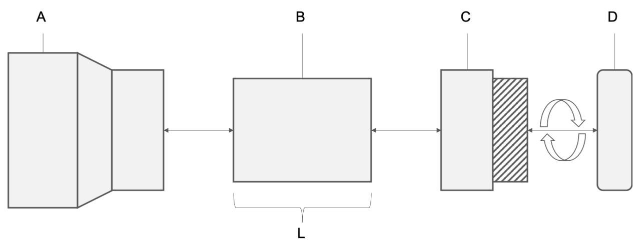

Figure 2.2: PVC didgeridoo construction

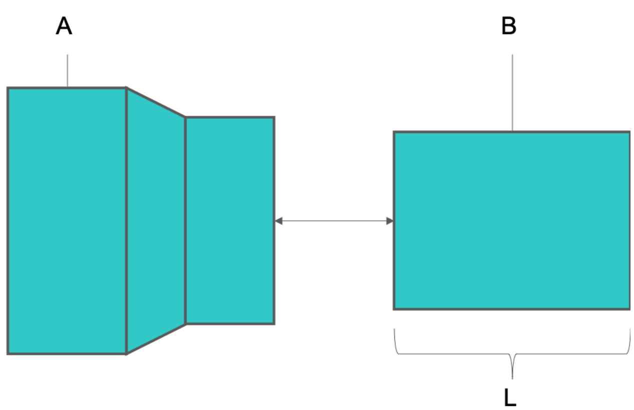

Figure 2.3: PVC didgeridoo construction, part A

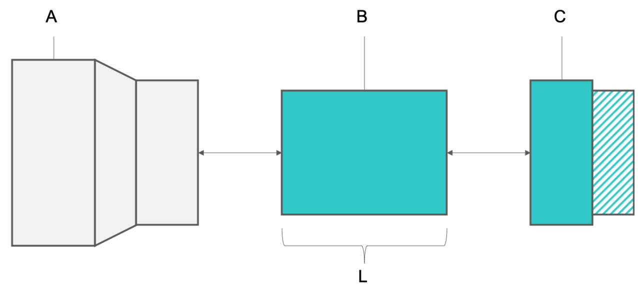

Figure 2.4: PVC didgeridoo construction, part B

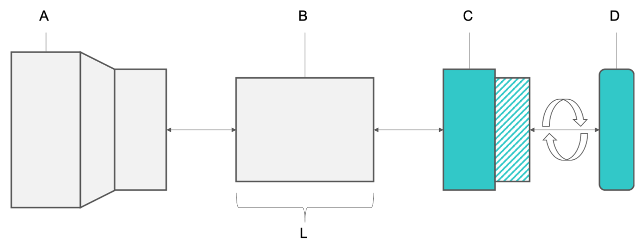

Figure 2.5: PVC didgeridoo construction, part C

2.5 Standard Form

While traditional hollow-branch didgeridoos are generally straight, the PVC didgeridoo can be created in many forms. The standard straight form is the simplest design with a single length of pipe connecting the mouthpiece to the flared bell (our reducing coupling) at the opposite end.

2.6 Alternative Forms

Alternative forms can result in more compact, twisted variations. These forms require extensive cutting and the use of angled fittings. One example is presented here for inspiration. With these forms, students can create longer didgeridoos and deeper, more resonant notes while occupying minimal space. What new form can you create?

2.7 Tuning

According to Didjshop (2016), the length of a didgeridoo for a particular desired frequency (also called the "key" of the didgeridoo) can be found using the formula $l = c/4f$ where l is the length in meters, c is the speed of sound in meters per second, and f is the desired frequency in Hertz (or key). We'll do our calculations using the metric system so, as an example, let's find the length of a didgeridoo that will play in the key of E (82.41Hz). We can do this by solving for the equation $l = 344/(4 * 82.41)$. We use 344 m/s because that is the speed of sound in dry air at a temperature of 20 degrees C. Solving this gives us a didgeridoo length of 344/329.64 or about 1.04 meters. It's good practice to start with a didgeridoo that is longer than needed and then you can cut and sand the PVC pipe to the desired length and key. See below for a data table of keys,

Figure 2.6: PVC didgeridoo; standard form

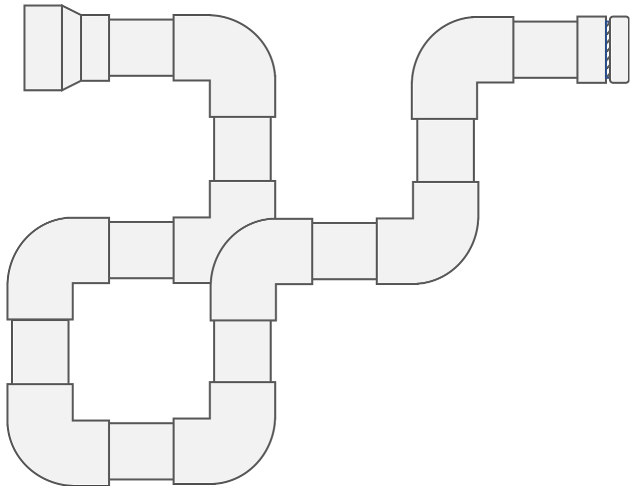

Figure 2.7: PVC didgeridoo; standard form

Figure 2.8: Didgeridoo decorations. Photo by Bernard Spragg, NZ. Public Domain.

frequencies (Hz), and estimated pipe lengths (mm). To estimate the key for a didgeridoo of a known length, solve the formula for f instead to get $f = c/4l$ where l is again the length of the didgeridoo in meters.

2.8 Decoration

According to Harris (2013), the didgeridoo may be decorated. Many designs are inspired by nature and traditional pigments contributed an array of earth-tone hues to the instrument. See Figure 2.8 for some examples.

2.9 Play

At the most basic level, the didgeridoo is a very simple tube, traditionally a hollowed-out eucalyptus branch or trunk eaten away from the inside by termites. This wind instrument, also classified as a brass aerophone, is deceptively simple however. The physical characteristics of the instrument, paired with the skill of the musician, allow for a wide variety of sounds that may incorporate percussion, vocalization, and intricate droning techniques. For more information on terminology such as resonance, backpressure, and different

Table 2.1: Musical key, frequency, and estimated didgeridoo length.

Key	Frequency (Hz)	Length (mm)
C	32.70	2630
C#	34.65	2482
D	36.71	2342
D#	38.89	2211
E	41.20	2087
F	43.66	1970
F#	46.25	1859
G	49.00	1755
G#	51.91	1657
A	55.00	1564
A#	58.27	1475
B	61.74	1393
C	65.40	1315
C#	69.30	1241
D	73.42	1171
D#	77.78	1106
E	82.41	1044
F	87.31	985
F#	92.50	930
G	98.00	878
G#	103.82	828
A	110.00	782
A#	116.54	771
B	123.47	696
C	130.81	657
C#	138.59	620
D	146.83	586
D#	155.56	553
E	164.81	522

types of notes, investigate the information presented by Gallery (n.d.). These concepts may help students to think of some methods they can try to incorporate into their playing style.

It's a great idea to watch some videos online to hear musicians play different styles, different instruments in a variety of keys, and to hear artists practice as a band. One popular channel on YouTube is DidgeridooBreath.

Here's a video of Sanshi providing a good intro to the didgeridoo:

Sanshi plays a lot of didgeridoo demonstrations to provide customers with an idea of how each instrument sounds. Here's a video entitled "Ellswood Didge C (No.2202) Didgeridoo Demo."

A didgeridoo is featured in "Dariya" performed here as a Tiny Desk Concert entry by Maharajah Flamenco Trio from Tallahassee, Florida, USA. Performed by Ramin Yazdanpanah on cajon & didgeridoo, David Cobb on bass, and Silviu Ciulei on guitar.

Chapter 3

Climate Data

3.1 Overview

A wealth of climate change information is available online and students should be encouraged to conduct their own investigations of topics they find interesting. As the theme of this activity is wind, a few NASA resources have been collected for review. Students are expected to draw inspiration from these resources for the purpose of creating a musical piece for performance with their PVC didgeridoo and/or paixiao.

3.2 Data Perceptualization

Quantitative data, in the form of a sea numbers, are usually messy, bloated, and difficult to understand without imposing some kind of order upon them. Humans therefore, tend to take advantage of our exceptional visual-spatial processing capabilities and create colorful visualizations to represent the data in a more meaningful way for easier understanding and communication across groups.

As an example, we can look at a land temperature data visualization presented by Rosenman (2017). In this plot, we see a few notable features. First, the x axis represents each the years 1850 to 2015. The y axis represents the Global Average Temperature in Celcius. Black data points are presented for each year, restricted to only the United States. Each data point is paired with error bars representing uncertainty in that calculated value. We can observe how the uncertainty, or the distance between the maximum and minimum value of the error bars decreases over time. This might be due to our increasing sophistication in measurement tools and perhaps the sheer number of data points collected each year. Another feature we see is the meandering line and blue shaded region. The line represents a smoothed average over time and the blue shaded region represents the 95% confidence interval around that average. This line and shaded region are used to provide an idea about a trend in the data set. Hopefully, this type of scatterplot visualization can more easily inform the viewer about any patterns in the data that might be of interest versus the raw data.

Visualization is not the only method for understanding data, however. We may also use a process called sonification (Nees and Walker (2012)) to transform data into sound. This method offers advantages over visualization for recognition of time-based patterns and changes. This is important when dealing with very long time frames on the geologic time scale.

As an example of a sonfication of climate data for popular consumption, listen to "134 Years of Global Temperature Change in 14 Seconds" by Nelson Guda (Guda (n.d.)) for [Threshold] (https://nelsonguda.com/project/threshold/), a data art project about climate change. In this piece, "the piano notes are the annual temperature data from 1850 − 2015"," and "the orchestra plays chords made of the minimum, mean and maximum temperatures for eight year intervals over that time period." The data are sourced from The Berkeley Earth Data site (Study (n.d.)).

TODO: expand https://power.larc.nasa.gov/ https://climate.nasa.gov/evidence/

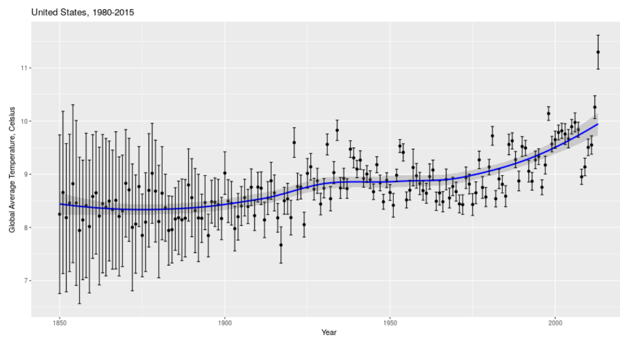

Figure 3.1: Global Average Temperature by Year, United States

3.3 Reading: Fire and Ice

TODO: expand https://climate.nasa.gov/news/2631/wind-warm-water-revved-up-melting-antarctic-glaciers/ https://climate.nasa.gov/news/2791/a-world-on-fire/ https://climate.nasa.gov/news/2284/airborne-mission-to-focus-on-polar-

Chapter 4

Music

4.1 Climate Data as Inspiration

TODO

Students should look to the suggested climate data resources, or other reputable information, for inspiration to create a musical piece to be performed with their PVC instruments. Students should be allowed maximum creative freedom to interpret their data in musical form but some suggestions include converting wind speed changes into pitch variation, temperature into tempo, or spikes into percussion. Students should brainstorm and work among small teams to document their data source, their method of interpretation, and their data-to-music philosophy.

4.2 Performance

TODO

Students will perform in small teams. A team leader should announce the piece and include a brief informative talk about the data source and how it was used to inspire the musical performance.

Chapter 5

Materials and Tools List

This chapter describes the materials and tools needed to construct a basic PVC didgeridoo and a basic PVC paixiao.

5.1 PVC Didgeridoo

5.2 PVC Paixiao

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Fletcher, N. 1996. "The Didjeridoo (Didgeridoo)." *Acoustics Australia* 24 (1): 11–15. https://www.acoustics.asn.au/journal/1996/1996_24_1_Fletcher.pdf.

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Harris, Matthew. 2013. "The Didgeridoo." didjiman.com. http://didjiman.com/didjeridu/.

Hopkin, Michael. 2005. "Physicists Learn Secrets of Didgeridoo." nature.com. https://www.nature.com/news/2005/050704/full/news050704-7.html.

Nees, Michael, and Bruce Walker. 2012. "Theory of Sonification." In, 9–39. http://sonify.psych.gatech.edu/~ben/references/nees_theory_of_sonification.pdf.

Rosenman, Dave. 2017. "Climate Change: Land Temperature Data, 1850-2015." kaggle.com. https://www.kaggle.com/daverosenman/climate-change-land-temperature-data-1850-2015/data.

Study, The Berkeley Earth Surface Temperature. n.d. "Berkeley Earth Data." berkeleyearth.org. http://berkeleyearth.org/data/.

Tarnopolsky, A., N. Fletcher, L. Hollenberg, B. Lange, J. Smith, and J. Wolfe. 2005. "Acoustics: the vocal tract and the sound of a didgeridoo." *Nature* 436 (7047): 39. https://doi.org/10.1038/43639a.

Table 5.1: Materials for constructing a PVC Didgeridoo.

Materials	Specifications (Imperial)	Quantity or Length (Imperial)
PVC pipe	1.5", Schedule 40	10’
PVC trap adapter	1.5", Schedule 40	1
PVC Reducing Coupling	3.0"x1.5", Schedule 40	1
Sandpaper Medium Grit	Medium Grit	as needed
Sandpaper Coarse Grit	Coarse Grit	as needed
Alcohol Prep Pads	-	as needed

Table 5.2: Tools for constructing a PVC Didgeridoo.

Name	Specifications (Imperial)	Quantity (Imperial)
PVC Reamer	> 1.5"	1
Hacksaw	small	1
Digital Tuner	multi-instrument, clip-on or phone app	1
Permanent markers, multicolor	any color	any
Safety glasses	polycarbonate, ANSI Z87.1-2015 or similar	1 pair per student