Make Some Waves

Exploring Wave Interference With Synthesizers

James Doyle, Heather Shaffery, Ryan Rahhal
Published by *K20 Center*

This work is licensed under a Creative Commons CC BY-SA 4.0 License

Grade Level	10th – 12th Grade
Subject	Performing Arts, Science
Course	Music, Physics

Essential Question

How do synthesizers manipulate the properties of waves to create different sounds?

Summary

In this lesson, students examine the physics behind synthesizers and apply that knowledge to create unique sounds on a virtual synthesizer. As this lesson explores both scientific and musical concepts, it could be used in both science and music classrooms.

Snapshot

Engage

Students anticipate learning by listening to several synthesizer sounds from famous songs and other media.

Explore

Students explore oscillators, read a short article on the science of synthesizers, and record their learning using the Stop and Jot strategy.

Explain

Students examine the concepts of wave interference, principle of superposition, destructive interference, and constructive interference through the use of a Wave Addition and Interference simulation.

Extend

Students apply their new knowledge by adjusting the parameters of a synthesizer, manipulating waves and creating sounds to match a range of moods.

Evaluate

Students reflect on their learning by completing an Exit Ticket.

Standards

Oklahoma Academic Standards (Fine Arts: Music (Middle School to High school (Novice)))

M.PR.3 : Develop and express personal interpretations that consider creators' intent.
N.M.PR.3 : Identify expressive qualities in a varied repertoire of music that can be demonstrated through prepared and improvised performances.
M.PR.5 : Perform expressively, with appropriate interpretation and technical accuracy.
N.M.PR.5 : Demonstrate attention to technical accuracy and expressive qualities in prepared and improvised performances of a varied repertoire of music.

Oklahoma Academic Standards (Fine Arts: Music (Middle School to High school (Novice)))

PH.PS4.3 : Develop an argument for how scientific evidence supports the explanation that electromagnetic radiation can be described either by the wave model or the particle model, and in some situations one model is more useful than the other.
PH.PS4.3.DCI.1: Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other.

Attachments

- Exit Ticket—Make Some Waves - Spanish.docx
- Exit Ticket—Make Some Waves - Spanish.pdf
- Exit Ticket—Make Some Waves.docx
- Exit Ticket—Make Some Waves.pdf
- Lesson Slides—Make Some Waves.pptx
- Stop and Jot—Make Some Waves - Spanish.docx
- Stop and Jot—Make Some Waves - Spanish.pdf
- Stop and Jot—Make Some Waves.docx
- Stop and Jot—Make Some Waves.pdf
- Wave Addition Simulation (Teacher Guide)—Make Some Waves.docx
- Wave Addition Simulation (Teacher Guide)—Make Some Waves.pdf

Materials

- Lesson Slides (attached)
- Wave Addition Simulation Teacher Guide (attached)
- Stop and Jot handout (attached)
- Exit Ticket handout (attached)
- Internet-connected devices like tablets or laptops
- Headphones

10 minutes

Engage

Use the attached **Lesson Slides** to guide the lesson.

Display slides **2-4** and discuss the Essential Questions and Lesson Objectives.

Display **slide 5** and have students navigate to the following Choice Board on Wakelet: "Synthesizer Choice Board."

Have students spend about 5-7 minutes watching the videos or video sections of their choice. The options include songs, videos, and introductions to a few famous synthesizers. Emphasize to students that this time is exploratory and low-stakes, and they should not be concerned if they run into vocabulary or concepts that they are not sure about.

20 minutes

Explore

Distribute the attached **Stop and Jot** handout. Display **slide 6** and introduce the Stop and Jot strategy. Have students follow the instructions on the slide, navigating to the Chrome Music Labs website on their devices and answering the question on the handout.

Display **slide 7**. Instruct students to follow the directions on the slide, navigating to the iZotope article on their devices and using the reverse side of the handout to summarize each section.

20 minutes

Explain

Display **slide 8** and have students navigate to the Wave Addition and Interference simulation. Instruct students to experiment with the "Standing T," "Destruct," and "Construct" modes by adjusting the wave property sliders for either or both waves (frequency, wavelength, velocity, amplitude). The third wave (1 + 2) is the "wave sum" and shows the actual wave produced when the two individual waves interact. Students should be looking for patterns in how the two waves interact with one another.

Teacher's Note

Students should already be familiar with the anatomy of a wave (trough, crest, node) and wave properties (frequency, wavelength, amplitude). The simulation can be used to review these features if students need a refresher before beginning the exploration.

Display **slide 9**.

After students have had some time to explore the simulation, discuss the following questions as a class:

- What happens when two crests pass each other? Two troughs?
- How does the wave sum change when crests and troughs do not align perfectly?
- How does changing the amplitude affect the wave sum? The frequency? The wavelength?

Go to **slide 10**. Introduce the concepts of wave interference, principle of superposition, destructive interference, and constructive interference. Display **slide 11**. Refer back to the Explore reading. Ask students how wave interference relates to what they read about how synthesizers use oscillators. Guide students to the conclusion that synths work by using wave interference to produce different waveshapes (i.e., stacking oscillators), and that these are called additive synthesizers.

Teacher's Note

The simulation has options to model square and triangle waveshapes, seen previously in the lesson. Time permitting, consider a demo or giving students an opportunity to explore these waveshapes.

Optional Video

The following video goes into further detail about the science of music, including more discussion of wave behavior and harmonics: "The Physics of Music: Crash Course Physics #19." It is likely too much content for most students, but excerpts may be useful for more advanced classes or to provide you with background information as a teacher.

Embedded video

https://youtube.com/watch?v=XDsk6tZX55g

30 minutes

Extend

Display **slide 12** and read the slide.

Display **slide 13** and play the video: "Cardboard Synthesizer Tutorial." Instruct students to navigate to the Cardboard Synth website and plug in their headphones.

Teacher's Note

The Cardboard Online Synthesizer will work on any device with the Chrome web browser, except for iOS devices. If your students are using iPads or iPhones to complete the assignment, have them download the free app “Mynth” and show this video instead of the video for Cardboard: https://www.youtube.com/watch?v=C6VxPtM5o6g.

Embedded video

https://youtube.com/watch?v=L2g38xtag9Q

Upon getting to the website and applying their headphones, have students manipulate the synth’s parameters in order to create a sound that best represents the word "happy" to them. Using the Airplane Landing strategy, select three students to share their sounds with the class. After a brief discussion, remind students that they can have different ideas on how to represent the words, have them repeat the activity with the following words: **angry**, ***growl*** and ***sleepy.***

Teacher's Note

If the students enjoy making music in this way, our K20 LEARN platform has Tech Tool resources for both GarageBand (for macOS and iOS) and Bandlab for Education (Windows, Mac, and ChromeOS). Garageband features several virtual synthesizers with stripped down parameters which can be great for learning basic sound manipulation. Additionally, we have a lesson dedicated to creating music from loops using the BandLab for Education platform titled "Loop Me In."

10 minutes

Evaluate

Distribute the attached **Exit Ticket** handout. Display **slide 15**. Using the Exit Ticket instructional strategy, have students respond to the following questions and submit their responses on the way out.

- What did you change to make each patch sound?
- Why did you select those parameters?
- What does changing the frequency do? The wavelength? The amplitude?

Resources

- Crashcourse. (2016, Aug 11). The physics of music: Crash course physics #19. PBS. (YouTube). https://www.youtube.com/watch?v=XDsk6tZX55g
- Dixon, D. (2018, July 17). "The beginner's guide to synths for music production." iZOTOPE. https://www.izotope.com/en/learn/the-beginners-guide-to-synths-for-music-production.html
- GSN Composer. (n.d.). Cardboard online synth. https://www.gsn-lib.org/apps/cardboardsynth/index.html
- Kirby, M. (n.d.). The physics classroom. (interactive website). https://www.physicsclassroom.com/Physics-Interactives/Waves-and-Sound/Wave-Addition/Wave-Addition-Interactive
- K20 Center. (n.d.). Airplane Landing. Strategies. https://learn.k20center.ou.edu/strategy/78
- K20 Center. (n.d.). BandLab for Education. Tech Tool. https://learn.k20center.ou.edu/tech-tool/2235
- K20 Center. (n.d.) Choice Board. Strategies. https://learn.k20center.ou.edu/strategy/73
- K20 Center. (n.d.). Exit Ticket. Strategies. https://learn.k20center.ou.edu/strategy/125
- K20 Center. (n.d.). Garageband. Tech Tool. https://learn.k20center.ou.edu/tech-tool/1769
- K20 Center. (n.d.). Loop Me In. Lesson. https://learn.k20center.ou.edu/lesson/2223
- K20 Center. (n.d.). Stop and Jot. Strategies. https://learn.k20center.ou.edu/strategy/168
- K20 Center. (n.d.). Quick Write. Strategies. https://learn.k20center.ou.edu/strategy/1127
- K20 Center. (2022, October 25). Mynth synthesizer tutorial. https://www.youtube.com/watch?v=C6VxPtM5o6g
- *Oscillators.* (n.d.). MusicLab. https://musiclab.chromeexperiments.com/Oscillators/
- *Wave Interference.* (n.d.). CK-12. https://flexbooks.ck12.org/cbook/ck-12-physics-flexbook-2.0/section/11.5/primary/lesson/wave-interference-ms-ps