**ACTIVITY: Making Mexican waves**

**Activity idea**

In this activity, students use a Mexican wave to demonstrate how waves transfer energy and to visualise the wave behaviours of reflection, constructive interference and shoaling.

By the end of this activity, students should be able to:

* explain that a wave transfers energy without transferring mass
* demonstrate how reflection causes waves to ‘bounce back’
* demonstrate how constructive interference leads to increased wave amplitude
* demonstrate the effect of shoaling on wave amplitude.

[Introduction/background notes](#Introduction)

[What you need](#need)

[What to do](#Do)

[Discussion questions](#QUESTIONS)

**Introduction/background**

All waves have certain fundamental similarities. They all transfer energy without the overall movement of material (such as water molecules), and they all have certain characteristic behaviours (such as reflection, refraction, diffraction and interference).

Wave behaviours can help us understand how water waves interact with land. In the deep ocean, tsunamis and wind-generated waves settle to quite steady predictable wave patterns. However, as they approach the complex coastline of New Zealand, they can refract, diffract, be reflected and interfere with one another. Together, these behaviours direct the course and effects of waves (including tsunami waves) around New Zealand’s coast.

Performing a Mexican wave gives students the opportunity to learn about wave characteristics by participating in a simulation of a wave. It is an ideal way to introduce and discuss modelling and why scientists (like those profiled in Tsunamis and Surf) use models in their research.

**What you need**

* Access to the articles [Waves as energy transfer](https://www.sciencelearn.org.nz/resources/120-waves-as-energy-transfer), [Behaviour of waves](https://www.sciencelearn.org.nz/resources/121-behaviour-of-waves) and [Tsunami shoaling](https://www.sciencelearn.org.nz/resources/596-tsunami-shoaling)
* An open space in the classroom or outside where students can line up
* A classroom or gym with a mirror (optional)
* video camera (optional)

**What to do**

1. Introduce the purpose of the activity – to explore the characteristics of waves.
2. Read and discuss the information contained in the articles [Waves as energy transfer](https://www.sciencelearn.org.nz/resources/120-waves-as-energy-transfer), [Behaviour of waves](https://www.sciencelearn.org.nz/resources/121-behaviour-of-waves) and [Tsunami shoaling](https://www.sciencelearn.org.nz/resources/596-tsunami-shoaling) or have groups of students present the key points to the class.

1. Introduce the idea of using a Mexican wave to model wave characteristics and behaviours, then carry out some or all of the activities below.

***Energy movement in waves***

A common alternative conception among students regards wave movement and energy transfer. Some students think that, as a wave moves, the water itself moves. The water does move up and down as a wave passes, but water molecules don’t move significantly in the direction of the wave. Instead, the particles ‘take part’ in the wave by bumping into one another. This transfers the energy of the wave from one molecule to another.

To demonstrate how the movement of energy happens in a wave:

* Ask students to crouch side by side in a straight line.
* The student at one end begins a Mexican wave. The student stands briefly, raising her arms in the air, then crouches down as next the student stands, then crouches and so on.
* Just like the water molecules they represent, students move up and down as the energy moves from one to another, but they do not move along the room.
* To demonstrate a waveform more accurately, students can go sequentially from sitting to standing (wave crest) to crouching (wave trough) and back to sitting as the wave passes.

Consider doing this activity in front of a mirror (such as in the gym) so students can watch the wave as it moves along the line. If students are motivated to practise this activity (and/or the additional ideas below) to achieve a perfect wave, you could video their best attempts. Viewing the video provides opportunities to discuss the concepts of energy transfer without mass transfer and specific wave behaviours and to discuss the strengths and weaknesses of the Mexican wave as a model of wave characteristics.

***Demonstrating reflection***

Reflection occurs when a wave bounces back. Reflection of water waves at the coast occurs when waves strike a steep cliff or sea wall. The reflected waves tend to interfere with the oncoming waves. Because tsunami waves extend to the sea floor, they can also reflect off continental shelves, ocean ridges and large reefs under the sea.

To demonstrate reflection of waves:

* Ask students to line up side by side as per the Mexican wave activity above. This time, a student at the end of the line should stand near a wall, and the line of students should be perpendicular to the wall.
* The student at the front of the line begins as usual (use either the crouch-stand-crouch or sit-stand-crouch-sit version of the wave).
* As the energy reaches the final student, it ‘hits’ the wall and reflects – the wave bounces back, and the Mexican wave is reversed.

***Demonstrating constructive interference***

When two waves travelling in different directions meet, they combine their energies and form interference patterns. This can result in regions of very high waves when they add up (constructive interference) alternating with regions of diminished or no waves when they cancel out (destructive interference).

To demonstrate constructive interference of waves:

* Ask students to start a Mexican wave at either end of the line (use the crouch-stand-crouch version of the wave).
* The wave will meet at a single student, who should jump instead of standing. This demonstrates constructive interference (the amplitude of two waves that meet is added together to make the new waveform).
* Both waves should continue along the line after they pass through the jumping student.

***Demonstrating shoaling***

Shoaling is an increase in wave amplitude (wave height) that happens when water waves go from deep to shallow water – particularly at the coast. As the water gets shallower, the waves slow down and start to bunch together. As the wavelengths shorten, the waves get ‘squashed’ sideways so they get higher. Shoaling is one reason why tsunamis cause so much damage to coastal areas. Tsunamis have very long wavelengths in the deep ocean and involve large volumes of water in each wavelength. This is why tsunamis can shoal as high as they do when they reach the coast.

To demonstrate shoaling:

* Identify one end of the line as deep water and the other as the beach.
* Use either version of the wave. Ask the students to conduct a Mexican wave from ‘deep water’ to the ‘beach’.
* As the wave approaches the beach, it should get slower (each student delays longer in standing up after their neighbour has) and higher (students in ‘deep water’ should raise themselves only a short way off the seat, students in shallower water should stand tall, and students close to the ‘beach’ should jump).

**Discussion questions**

* How does energy move in water waves?
* How does reflection affect surf waves? How does it affect tsunami waves?
* How does shoaling affect the potential destructiveness of a tsunami?
* How useful is a Mexican wave as a model of wave energy transfer and wave behaviours? In what ways could the model be improved to be more accurate?
* What other wave behaviours could be modelled using a Mexican wave? How?