Teacher's Guide to Longitudinal and Transverse Waves (ver 2, 8/19/03)

OBJECTIVES:

1. The students will compare and contrast longitudinal and transverse waves.

2. The students will be able to predict changes in the Earth surface based on real-time or near-real-time earthquake data.

MATERIALS NEEDED:

Global Earthquake Explorer installed on computers with student access.
Seismogram from a classic earthquake (available on-line).
Seismogram from earthquake recorded on local seismometer (available on-line).
A simple, stick model, of a coordinate system may be helpful.

TEACHER INFORMATION:

1. Some detailed Background Information is available as on-line and print copies to help support teacher preparation for SCEPP exercises. It can be exported in PDF to your disk (along with other student materials) via a button on the Getting Started screen of this module.

2. Students may work alone if sufficient computers are available, but students may be more comfortable working in groups of 2 or 3 at each computer.

3. Prior to this lesson, students should be aware of the basic types of seismic waves, plate tectonics and the nature of the Earth's interior.

4. This lesson is based upon the premise that there might not be a very good seismogram available from your instrument. Therefore, we take the student first through the various steps using a classic seismogram. If in fact there is a good seismogram available from your instrument, you may disregard all references to the classic seismogram.

5. The initial Exploration Phase is nearly identical to the SCEPP Module "The Global Earthquake Explorer". This section may be done quickly if you have already completed that module.

6. Refer to the Student Instructional Guide for assistance with GEE software.

ENGAGEMENT

1. Explain to students that the local seismometer recorded an earthquake very recently. Have the students select and start the module "Longitudinal and Transverse Waves" within the Global Earthquake Explorer. Using GEE, show the students the seismogram that was recorded on that instrument.

2. <u>*Ask*</u>: What can we learn from this?
   Explain: Depending on the quality of the seismogram and the intensity and location of the earthquake, the students should be able to determine the arrival times of the principal wave forms, the properties of the waves and the location of the earthquake.

EXPLORATION PHASE

1. Explain: Remember from your 8th grade Earth Science class that an earthquake produces three kinds of waves – P, S, and surface waves. We want to examine the properties of these waves in more detail, so we are going to start with an earthquake that shows them very clearly.

2. Show the vertical component of the classic seismogram and <u>*Ask*</u>: How are the waves on this seismogram distributed?
   Explain: Note that the seismogram is essentially flat up to this "blip" (point out P wave). After that there are several other " blips".

3. <u>*Ask*</u>: What are these "blips"?
   Explain: The blips are arriving waves, recorded on the seismometer, that were generated by the earthquake. Seismologists call these "arrivals".

4. <u>*Ask*</u>: How are these waves different from one another?
   Remind students that a previous lesson covered that the P-waves and S-waves have different velocities, amplitudes, and periods using just the vertical ground motion. But, we can measure three-dimensional ground motion with many seismometers and this allows us to identify other differences between these waves.

5. Now have students select and display all three components of the classic seismogram.

6. <u>*Ask*</u>: Are there differences in the different waves on these different components of motion?
   NOTE: There will be differences in primarily amplitudes for the waves on different components. Due to variations in the distance and direction to different earthquakes, we cannot explain precisely in advance what you will observe.
   Explain: We can use these differences to learn even more about these waves.

CONCEPT DEVELOPMENT PHASE

1. Explain: First, we need to take some time to make sure we understand what the three components are measuring. Each is installed to be sensitive to ground motion only in one direction. The three seismometers are installed so they are mutually perpendicular. In a sense, they form a COORDINATE SYSTEM in which we describe ground motion. Using all three components, we can not only describe the amplitude of the ground motion but also the direction of that motion. [Construction of a simple stick model of a coordinate system may help students grasp this concept].

2. Have the students select one of the "Particle Motion Animation" items under the Extras menu. Each of these will pop up a window where the students see the relationship between actual ground motion and the resulting seismograms. To run the animation, students need to press and hold any key on their keyboards. There is a slight time lag between when the key is released and the animation stops, but with some trial and error, you can pause the animation at various spots to illustrate what is going on. Lead the students through these selections, asking them in advance to predict what the seismogram will look like. Repeat animations to help students grasp the relationships.

3. At the end of the animation, *Ask*: If we want to know the relationship of ground motion to the DIRECTION from the station to an earthquake, what components of motion would we look at?
   Explain: We would use the two HORIZONTAL components of motion since these are similar to a map.

APPLICATION PHASE

1. Have the students zoom their display to allow them to clearly observe one PERIOD around the P-wave. Have students draw a window around the first half-period of the P wave.

2. Have students create 'Particle Motion' animation. Explain that the little moving ball or dot on the computer screen is determining and plotting the direction that the ground is moving at any one time. The **straight** line crossing the screen shows the direction, or azimuth, from the station to the earthquake.

3. *Ask*: What is the relationship between the P-wave particle motion and the direction to the earthquake?
   Explain: The P-wave motion is [roughly] along the direction that the wave traveled from the earthquake to the station. This is called "particle motion parallel to the direction of propagation" and it is the definition of a **longitudinal wave.** This is the same type of motion displayed by SOUND WAVES. P-waves are just sound waves traveling through the earth.

4. Returning to the classic seismogram, have the students pick one station's horizontal components of motion. Instruct them to display the map to see the relationship of their station to the earthquake.

5. Repeat steps (2) and (3) for the S wave. Both analyses will be plotted on the screen simultaneously.

6. *Ask*: What is the relationship between the S-wave particle motion and the direction to the earthquake?
   Explain: The S-wave motion is [roughly] orthogonal to the direction to the earthquake. This is called "particle motion perpendicular to the direction of propagation" and it is the definition of **transverse waves.** Transverse waves are generated by shearing forces in solid materials, such as the motions that are generated when faults move.

7. If time permits, students can look at other stations and verify these relationships.

EXTENSIONS

Are surface waves longitudinal or transverse waves?
Which way did an earthquake come from?
Determining Angle of Incidence using particle motion plots.