TRANSCRIPT

BLOSSOMS VIDEO:
CAN EARTHQUAKES BE PREDICTED?

Hi, and welcome to our Blossoms video on earthquakes. I'm Zach Adam, and I'm an Earth and Space scientist with Teachers Without Borders. Every year, thousands and sometimes millions of people wake up to find that their communities have been destroyed by the release of more energy than the largest atomic bomb ever created. Houses are destroyed, buildings have collapsed, entire cities and communities are shattered.

Now, if someone told you at some point in your life that this type of energy release was going to occur, you would demand to know, why, and what can I do to proactively prepare for it?

Well, this release of energy I'm talking about is not attributed to climate change; it's not attributed to aliens attacking from outer space; it's not attributed to war. What I'm talking about is earthquakes. And even if you're not exposed to earthquakes in your community right now, chances are that someone you know is exposed to earthquakes, and chances are that you'll be traveling to an area that is prone to earthquakes, at some point in the future.

So, what we're going to talk about in this module today are some of the basic properties of earthquakes. Why do earthquakes occur? Can they be predicted?

Why don't you take a minute to go over some of the key concepts of earthquakes with your teachers that will allow us to begin the module. These key concepts are plate tectonics, plate motion and faults, material properties, and seismic energy.

Also, take a few minutes to talk about earthquake exposure in your community.

- Has anyone in your classroom ever experienced an earthquake?
- Do you know someone who has?
- What was it like?
- What happened during the earthquake or immediately afterward?
- Do you live near a plate boundary or active fault right now?
- Is it important to learn about earthquakes? Why, or why not?

We'll see you after the break.

Welcome back!

Now that you've had a chance to discuss earthquake exposure in your community or other reasons why it's a good idea to understand earthquakes, we're going to gather and assemble the materials we need to complete the setup. All these materials are simple, inexpensive, and can be found at most hardware stores.

The materials you're going to need are: a tape measure, a rubber band, 2 wood blocks with eye screws, a piece of sandpaper, and a sanding belt.

So to get the setup constructed, you're going to secure the sanding belt to the surface of the table. You're going to take the wooden block, with the sandpaper glued to the bottom, and apply it face down with the sandpaper surfaces touching, to the sanding belt. The block with the eye screw on it goes at the end so that the eye screw itself is mounted toward you, mounted horizontally, and you're going to take the rubber band and apply it to the end of the tape measure, like this, so that it can be threaded through the eye screw and attached to the other eye screw that's on the sandpaper block. At that point, you have your setup constructed.

To operate the setup, you're going to pull smoothly and steadily on the tape measure, and at that point your setup will be ready to go.

But before you run the setup, we're going to ask you to predict what's going to happen to the setup. Some of the key concept challenge questions are:

- What's going to happen when you pull smoothly and steadily on the tape measure?
- Why is the system going to behave that way?
- Can you describe the energy flow through this system? Where is the energy going in and where is it going out?

After you're had a chance to discuss what your predictions are, to explain why your predictions are going to occur, and then compare it to the actual behavior of the setup, we'll come back to see how you've done and how your predictions matched up to the actual behavior of the system.

Welcome back!

Let's see how well you did predicting and explaining the behavior of the system.

This is what's known as an analog system. It's a simplified representation, or model, of another much more complex system that may be impossible or difficult to directly imagine or observe. And by observing the behavior of our simplified system, we can extrapolate about the behavior of this much more complex system.

So looking at our system, what we see is that a smooth, steady input into the system by pulling on the tape measure, causes the block to move forward every now and then in amounts that really aren't predictable ahead of time. The smooth pulling on the end of the tape measure does not result in a smooth motion of the block moving forward. So basically, what's going on here is that as we apply tension into the system, the very complex, irregular surfaces of the sandpaper and the sanding belt are preventing a smooth forward motion from going forward, because the surfaces are very complicated and they lock together. And because the surfaces themselves are very complicated, they're very difficult to quantify and predict.

What happens in terms of energy flow through the system is that the energy is put into the system as you pull on the tape measure, the energy is transferred to the rubber band where it accumulates as elastic energy, and after reaching a breaking point the block suddenly releases, moves forward, and then comes to a halt.

So now that we understand the function of the system, and the path of energy flow through the system, it's time to figure out how we are going to apply the concepts and behavior that we see in our simple system to an earthquake, and what happens when an earthquake occurs.

Some of the key concept challenge questions that you might want to ask now are:

- What does the wooden block represent?
- What does the rubber band represent?
- What does the smooth pulling motion of the tape measure represent?
- What about the complex surfaces of the sandpaper and the sanding belt?
- Where in this system is friction observed?
- What does the movement of the block represent?
- Can this movement be predicted?

So go over some of these questions and extrapolate, based on your knowledge of the simple system, to an earthquake system.

We'll come back and discuss how well you did.

Welcome back!

Now that you've had a chance to answer the questions posed to you before the break, we'll go over them and see how our analog system is useful for visualizing earthquakes and answering the question: Can earthquakes be predicted?

But before we go to the analog system, we should review what we know about the earth itself, and the behavior of the crust.

The earth's surface is broken up into pieces. Scientists call these pieces "plates." The plates move relative to each other. This is called "plate tectonics." These plates themselves can deform, or change shape, as a result of these plate motions, and can store energy as they deform and change shape. But sometimes they don't deform; sometimes they break. These breaks in the surface are called "faults." And when motion occurs relative to this fault, a displacement can occur, and that's when earthquakes can occur.

So let's look at our analog system, and look at the connections we can make between the large behavior of the earth and small behavior of our analog system.

The wood block with the sandpaper represents an active fault section. As the student pulls on the tape measure. This is an analog for the large scale movement of plate motions that can occur on the surface of the earth. These plate motions can cause deformation of the materials surrounding the fault as represented by the rubber band, and the accumulation of elastic energy within the rubber band. Friction occurs at the fault contact surface, at the active fault section, as observed here between the sandpaper and the sanding belt. The movement of the block itself represents an earthquake, the release of seismic energy along a fault. But how and why does this energy build up? What we see in the set up is that the build up of the energy occurs because friction between the block and the sanding belt do not allow the forward smooth motion of the block. This is basically an analog for an earthquake. So based on what you've seen here, we can ask the question, "Can earthquakes be predicted?" Take a minute to discuss it amongst yourselves and we'll come back and wrap up the lesson.

Welcome back. Now that you've thought about whether or not earthquakes can be predicted, let's see what the analog system can tell us. Basically the frictional surfaces between the sandpaper and the sanding belt are highly irregular and therefore they cannot be easily predicted in terms of what the final resulting motion is going to be as these two surfaces interact with each other, despite the fact that we're inputting a smooth, steady and predictable amount of energy as we pull on the tape measure. There's a direct analogy that can be made here for earthquakes. Along a fault, the fault surfaces that interlock with each other are very complex and in many ways resemble the complex frictional surfaces of the sandpaper and the sanding belt. As the energy builds up in the crustal material surrounding a fault, while this motion can be observed, predicted and measured to some extent, due to the smooth motion of the plates relative to each other, the nature of the release of this seismic energy as earthquakes cannot be predicted. So therefore we'll see that an earthquake can either be one big release of seismic energy corresponding to a big earthquake, or a series of smaller earthquakes over time that generally dissipate the energy that accumulates in the crustal material.

So in conclusion, we've basically covered three main concepts through our use of the analog system. The first is that the earthquakes that occur in earth are the result of the buildup of elastic energy in crustal material which is released unpredictably along faults and which causes the dissipation of this elastic energy as seismic energy. What we've done is construct an analog setup which is a simplified setup to represent a more complex situation that's difficult to directly observe or imagine. It's important to note though that there are limitations to using a simple setup to represent a complex setup. And therefore it's important to note the strengths and weaknesses of using a simple setup to investigate more complex phenomena.

Before concluding this activity I'd like to leave you with a few reflection questions that will help you explore the limitations of using this analog setup to explore and explain the behavior of earthquakes. What are some of the strengths and weaknesses that you observed using this analog setup? What did the setup teach you that you didn't already know? And if you were going to use this setup to investigate other questions or if you were going to modify this setup in some way, why would you modify it, how would you modify it, and what would that teach you about earthquakes? I encourage you to investigate whether or not your community, your school or your family already have in place an earthquake emergency plan. If you don't have an emergency plan I'd encourage you to look into developing one that's based on the particular needs of you, your community and its built in response to the particular geologic setting that you live in. I hope you've learned a lot using this setup. It's easy to feel powerless about earthquakes because they are unpredictable, but earthquakes are a unique facet of our dynamic planet. It's a unique facet of a planet that provides for our needs on a day-to-day, year-to-year basis. Just because earthquakes occur doesn't mean that we can't prepare and be proactive about how we're going to respond to them. Thank you and goodbye.

Hi! I'm Zach Adam with Teachers without Borders. I want to thank you for considering using this module. And we put together this teacher's guide to help you through some of the background information that's necessary to complete the setup, or maybe to warn you about some of the pitfalls that we've experienced when implementing this setup ourselves. This setup takes about 50 minutes to implement, provided that you've put together the basic materials and gathered them in one place and are ready to go on the day of implementing the lesson. It's important also to note that there are some prerequisite concepts that the students should be aware of before beginning this lesson. This includes earth's interior structure, plate tectonics and plate motions, the properties of earth's materials and faults and fault motions. If you need some help looking for more information or references concerning these concepts, you can see some of the reference materials that have been provided on the Blossoms video page.

Basically the teaching approach that's used in this lesson plan is called the 5E approach, the five E's standing for engage, exploration, explanation, elaboration and evaluation. In section one the students are asked to engage in the topic of earthquakes by recounting their own particular experiences with earthquakes or the experiences of others that they know. And relating that and developing relevance for why they should be understanding and studying earthquakes. It's especially important that students discuss these experiences prior to beginning the lesson plan to help build relevance. In section two students begin exploring and explaining the nature of the behavior of the analog setup and by sections three and four they're elaborating about how the behavior that they've observed in the setup might be applied to understanding or visualizing what's going on when an earthquake occurs. And in the final sections of the lesson plan they're evaluating their use of the analog setup to answer these questions and to make predictions about the nature of earthquakes. This basically comprises the entire five 5E approach.

As stated in the video, the procedures for building the setup required to conduct the module can be found in the resources that are included with the Blossoms video page. This includes the dimensions of the blocks, how much material is required and how to pre-assemble some of the components before you get started and present them to the students. It's important that the basic materials be constructed prior to starting the lesson plan but we really encourage you to leave the final assembly of the components to the students. That way they have a much firmer basis for predicting the behavior of the system once they start using the analog in the middle of the lesson plan. The materials that are described can easily be obtained at hardware stores and shouldn't cost much. We intentionally selected materials that can be found just about anywhere.

We also recommend that you make sure that you try this setup before implementing it in your class, mainly because the materials themselves that you pick out or that might be available to you might be different than the ones that we've used in the video. This might include sandpaper that has a different roughness or a rubber band that has a different elastic strength. Variations in these very important properties of the setup can result in behavior that's not exactly as observed in the video. For example a very stiff rubber band won't demonstrate the accumulation of much elastic energy. Or a sandpaper that's extremely rough might grip the wooden block so much that it can't move forward on a periodic basis. We also note that we found that what works best is to have sandpaper of different grits so that they have a good mix of gripping properties when combined with the rubber band and demonstrating the kind of lunging and halting motion of the wooden block that corresponds to an earthquake.

In sections three and four students will be making key concept connections between what's going on in the analog setup and what occurs along a fault during an earthquake. It's important to allow enough time to answer the questions that the students might have. In drawing together these connections, students might ask questions that come out of the blue or that to explain and elaborate upon the nature of what's going on in the analog setup and what that means in terms of behavior that occurs along an actual fault section. It's really important not to rush your responses to the student's questions at that time, so we really recommend leaving quite a bit of time to make sure everyone is on the same page.

It’s also important to note that this system only demonstrates horizontal displacement. And in fact even with this setup, with the fact that the sandpaper surfaces themselves are horizontal, for some students this might be a little confusing because faults can come in a variety of different orientations, horizontal, vertical and everywhere in between. This is also another common pitfall that you might want to be prepared to respond to when the students bring it up.

For more advanced students or students who want to further explore the setup, there are a number of different extension activities and questions that you might want to pose to them. For example some students may have a sufficient grasp of physics, depending upon where they are in their school training, that they might actually be at a level where they can begin to quantify some of the basic physical parameters of the system. Just as a suggestion, some of the properties that can be quantified include the elasticity of the rubber band, and the amount of energy that is stored for a given displacement of the rubber band, and the coefficient of friction measured between the wooden block and the sand belt surface. For the more creatively inclined students, you might consider challenging them to improve the model by asking how would they change this setup? Or what components would they switch out? Would there be some components that they would consider automating and what would be the resultant changes in the behavior of the system that you would observe as a result of those alterations? There are a wide variety of different changes that could be implemented in the system to answer different questions.

This basically wraps up the teacher’s guide for the module. If you have any questions, suggestions, difficulties or improvements that you’d like to suggest, please don’t hesitate to contact me at the email address that’s associated with this video package. Thanks and good luck implementing your module!

END OF TRANSCRIPT