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Supplement of

Using paired teaching for earthquake education in schools

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1. Additional Details on Methods

1.1 Paired teaching video example

To illustrate the paired-teaching approach used in this study, we provide below an example of a video module from our earthquake video series: *Journey to the Centre of the Earth* by Matthew Kemp from the University of Cambridge (see Table 1 in the manuscript text). The goal of this video lesson is to introduce students to fundamental scientific concepts behind earthquakes (i.e., plate tectonics and the driving mechanisms) in order to prepare them for topics covered in later videos (e.g., earthquake anatomy, associated hazards and mitigation measures).

The video module contains five video segments with five active learning exercises that take place in the classroom under the guidance of the in-class teacher. The active learning segments are based on questions and/or activities proposed by the video-teacher at the end of each video segment. In addition, a teacher's guide segment is included at the end of the video to help the in-class teacher prepare for the lesson. This video module is designed for a 60-minute-long class, with approximately 22 minutes given to the video-teacher and 28 minutes given to the in-class teacher for group exercises. Each video segment takes between 2-5 minutes. The in-class teacher (1) starts playing the video with students sitting in the classroom, (2) pauses the video at the end of each video segment, (3) facilitates the active-learning session with students in the classroom, and (4) resumes the video when the active-learning exercise is completed. The details of each segment follows.

Segment 1 (2 minutes): The video-teacher introduces himself. He then holds on to a large inflatable globe and shares some intriguing numbers about the size of the Earth (e.g., it would take about 11 years to walk around the Earth) and the Earth's spinning speed around its own axis and the Sun. He then entices students into thinking about the Earth's interior by holding a wrapped present and telling them, "[…] soon it is going to be my birthday and someone has kindly bought me a present, and of course I want to find out what is inside the present before that day itself." He tries out different strategies to figure out the content of the present (e.g., shaking it and holding it up to the light). He then pauses and asks students, "but what if I told you that I could never open this present? How would I actually find out what the present was?" Then he points at the inflatable globe, "that's a bit like how it is for scientists and the Earth. The Earth is like a gigantic present that they're never going to unwrap." He continues, "despite this difficulty, scientists know a lot about the Earth's interior structure and composition, and one way to study the Earth's interior is to drill a deep hole." The video-teacher ends the segment by asking students to discuss the following question in groups and under the guidance of their in-class teacher: How deep have scientists drilled into the Earth? [The video fades into black, the in-class teacher pauses the video and takes over the teaching]

Segment 2 (2 minutes): The video-teacher gives some insights into the question asked in segment 1, including sharing examples of drill projects from around the world and explaining some of the factors that hinder the drilling depth. To give a sense of scale, the video-teacher compares the deepest hole drilled into the Earth to biting an apple and barely breaking through its skin. The teacher continues by stating that despite not being able to drill deep into the Earth's interior, scientists know a lot about its internal structure and composition. At the end of this segment, the teacher asks

students to discuss the following question: What other methods do scientists use to learn about the interior of the Earth? [The video fades into black, the in-class teacher pauses the video and takes over the teaching]

Segment 3 (2 minutes): The video-teacher recalls how in segment 1 he tried to find out about the content of the wrapped present by shaking it and listening to the sounds he could hear. The video teacher relates this to how scientists use seismic waves to map the interior structure of the Earth. At the end of this segment, the video-teacher asks students to learn about different types of seismic waves and use a Slinky to model each. [The video fades into black, the in-class teacher pauses the video and takes over the teaching]

Segment 4 (5 minutes): In this segment, the video-teacher uses a 3D model of the Earth's cross section as a visualization tool to point out and describe each layer, and what (and how) scientists know about its composition. The video-teacher uses the Slinky to remind and demonstrate how seismic waves behave as they travel through different materials, and how scientists use that information to map each layer. The video-teacher ends this segment by inviting students to use a hard-boiled egg as a model of the Earth to list the different layers of the egg and relate these layers to those of the Earth. [The video fades into black, the in-class teacher pauses the video and takes over the teaching]

Segment 5 (4 minutes): The video-teacher shows a hard-boiled egg cut in half and relates each egg layer to a layer in the Earth. He then gently cracks the egg to simulate plate tectonics and plate movements. He points out the limitations associated with the egg model, and summarizes the lesson content. At the end of this segment, the video-teacher invites students to discuss the limitations of the egg model. He proposes a series of questions to guide the discussion: (1) how to modify the egg model to overcome its weaknesses, (2) what are the strengths of the egg model, (3) can you think of better analogies for the Earth, and (4) what did the egg model teach you that you didn't know already? [End of video intended for classroom use]

Teacher Segment (5 minutes): The goal of this segment is to assist the in-class teacher in directing the learning that takes place in the classroom. It is intended that this teacher segment would be viewed by the teacher prior to using the rest of the video for paired teaching. The segment starts with the video-teacher stating the lessons' pre-requisites and materials needed for classroom activities, and encouraging the in-class teacher to contextualize the content by incorporating examples and analogies that are more appropriate and relevant to students' lives. In addition, background information about seismic waves and how to produce them using a Slinky or an alternative teaching demo are shared.

Pre- and Post-Assessment Survey
Geoscience Video Modules

Thank you for completing this survey. Your participation will help your teacher and video presenters to understand your background knowledge of earthquakes and to assess the effectiveness of the videos in conveying useful earthquake information to you. This is an assessment of your independent thoughts and opinions. Please do not share your opinions about these questions with others until the survey has been completed and collected by your teacher.

Please **DO NOT** place your name on this survey. If you have any questions regarding your participation in this survey, please talk to your teacher or contact Solmaz Mohadjer at solmaz.mohadjer@gmail.com

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Your code name: _____

1. Please indicate your gender:

Female ☐ Male ☐

2. Please describe the cause(s) of an earthquake? _____

_____

3. In general, do you think it is possible to know where earthquakes can happen?

☐ Yes - ☐ No - ☐ Sometimes - ☐ I don't know - ☐ Other (specify: _____)

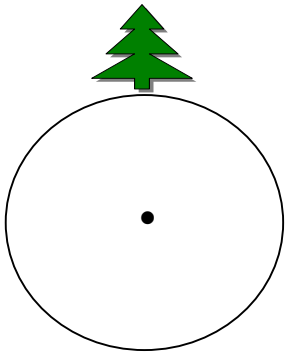
4. Do you think it is possible to know the exact timing of earthquakes before they occur?

☐ Yes - ☐ No - ☐ Sometimes - ☐ I don't know - ☐ Other (specify: _____)

5. Please describe where in the world you think earthquakes occur most often: _____

_____

6. The image to the right is a representation of the Earth. The circle represents the Earth's surface, and the dot is the very center of the Earth. On this picture please draw the Earth's interior.



7. Review the images below. Circle all potential non-structural earthquake hazards that you see. You may circle as many hazards in each image as you wish.

Photo credit: AKDN/DRMI (2011)

Supplementary Table 2a: Statistically significant results
Null Hypothesis: Students' responses to pre- and post-survey questions are not significantly different.

	Q2	Q3	Q4	Q5	Q6	Q7
Pre- vs. Post-assessment (Tajikistan)					**95%**	
Pre- vs. Post-assessment (UK)		**95%**				**95%**
Pre-assessment (Tajikistan vs. UK)	**95%**				**95%**	
Post-assessment (Tajikistan vs. UK)	**95%**			**95%**	**95%**	
Individual learning (Tajikistan vs. UK)						

Supplementary Table 2b: Statistical test results

	KS test D-stat | D-crit	McNemar test chi-stat | chi-crit
Q2: What are the causes of earthquakes?		
Pre-assessment (Tajikistan vs. UK)	0.84, 0.30	
Post-assessment (Tajikistan vs. UK)	0.79, 0.30	
Q3: Is it possible to know where earthquakes can happen?		
Pre- vs. Post-assessment (UK)		6.66, 3.84
Q5: Where do you think earthquakes occur most often?		
Post-assessment (Tajikistan vs. UK)	0.38, 0.30	
Q6: What is the interior structure of the Earth?		
Pre- vs. Post-assessment (Tajikistan)	0.32, 0.30	
Pre-assessment (Tajikistan vs. UK)	0.33, 0.29	
Post-assessment (Tajikistan vs. UK)	0.33, 0.30	
Q7: What non-structural hazards can you identify in the photos?		
Pre- vs. Post-assessment (UK)	0.44, 0.30	