Exploring Natural Hazard Policies with Bike Helmets and Bus Fares

A close look at everyday decisions—whether or not to wear a bike helmet or cheat on bus fare—helps students learn about assessing natural hazards, mitigating risks, and setting political priorities.

Natural hazard mitigation policies depend in part on perception of and tolerance for risk, which can differ between societies. These abstract-sounding concepts can be explored by asking students whether they wear bicycle helmets and why. In the authors' experience, American students are

most likely to report wearing helmets, British students less, and German students even less. Credit: Jim Crossley, CC BY-NC-SA 2.0

By Seth Stein, Jonas Kley, David Hindle, and Anke Friedrich 2 hours ago

Defending society against natural hazards is a high-stakes game of chance against nature, involving tough decisions. How should a developing nation allocate its budget between building schools for towns that have none and making existing schools earthquake resistant? Does it make more sense to build levees to protect against floods or to prevent new development in the areas at risk? Would more lives be saved by making hospitals earthquake resistant (http://www.npr.org/player/v2/mediaPlayer.html?action=1&t=1&islist=false&id=5407527&m=5407528) or by using the funds for patient care?

Such topics challenge educators teaching natural hazards classes for several reasons. They are far from students' experience because they involve rare events and large sums of money. They cross the lines between traditional academic disciplines. Unlike other academic exercises, many of these questions have no unique or right answers.

To help students at two German universities (the University of Göttingen and the University of Munich) to conceptualize such topics, we designed a class that posed thought-provoking questions about complex issues and explored them by analogy with students' daily decisions. Using lectures, news stories, field trips, and in-class questions, students delved into the concept of risk and how to choose policies to mitigate risks to help prevent natural hazards from causing disasters. A similar class (http://www.earth.northwestern.edu/people/seth/390/) starts at Northwestern University today.

Everyday Decisions Provide a Starting Point

We used the students' own experiences to make abstract concepts like risk perception, cost-benefit analysis, and alternative mitigation strategies more understandable.
We used a textbook (http://www.wiley.com/WileyCDA/WileyTitle/productCd-1118620828.html) [*Stein and Stein*, 2014] that covered topics in probability, statistics, economics, and risk analysis. Because most geoscience students have not studied these topics, we used the students' own experiences to make abstract concepts like risk perception, cost-benefit analysis, and alternative mitigation strategies more understandable.

For example, when asked whether they wear bicycle helmets (http://road.cc/content/news/85306-top-scientists-cycle-helmets-debate-will-go-and-and), most students said "no" because they view themselves as

skilled riders. This discussion gained unexpected immediacy when a student missed classes after a bike accident in which she sustained a concussion. The student returned and announced that she would now wear a helmet. We mentioned how similar informal surveys that we conducted show that a much larger fraction of American students wear helmets, and British students were in between the U.S. and German ones. We then generalized this example to discuss how societies' approaches depend on their perception of and tolerance for risk, which can differ between societies and vary significantly from actual risk.

Cost-Benefit Analysis

We explored the seemingly abstract concepts of expected loss (the product of a disaster's probability and the anticipated loss if it occurs) and cost-benefit analysis by examining a choice that students faced daily: Should they buy a ticket or sneak on the bus or subway?

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(left) Munich subway car. Credit: Anke Friedrich (right) A sign on a Göttingen city bus warning "Nice try. But fare cheating costs 40 euros." Credit: Seth Stein

Tickets cost 2 euros (€), but it is easy for a rider to avoid paying by not buying a ticket or sneaking on the bus through the back door. However, occasional inspections catch fare cheaters (schwartzfahrer (http://www.vice.com/read/resist-control-a-guide-to-riding-berlin-public-transportation-for-free)) and fine them 40€ (http://www.globalpost.com/dispatch/news/regions/europe/germany/140210/germany-black-riders-vs-kontrol). Students quickly understood comparing the benefit to the cost: saving the ticket price versus the expected loss if caught. However, they said we needed to tell them the probability of inspection and were puzzled when we did not know.

After discussion, they realized that by combining their experiences, they could reasonably estimate

the occurrence rate of an event that is rare on an individual basis. We then used this concept to estimate the probability of earthquakes, hurricanes, floods, and similar events from a limited historic record and the uncertainties involved.

Weighing the Options

We introduced alternative mitigation strategies using another familiar example: what students do with their bicycles when they take the train. Approaches range from not taking bikes to the station —risk avoidance—to using secure parking for 2€ per night, an expensive but high level of mitigation.

(https://eos.org/wp-content/uploads/2015/03/IMG_0397_embed-2_Web.jpg?ad8626)

Bicycle parking outside Göttingen train station. Credit: Seth Stein

Most students lock their bikes outside for free. This inexpensive solution provides a low level of mitigation, but most students consider it appropriate compared with the risk of theft. Garage users noted that a theft had a total cost that included both the actual cost and the effort of replacing the bike, leading to the concept of direct and indirect losses.

Who pays to replace a stolen bike, the students or their parents? This question led to a discussion of transferring risk via insurance. We extended this concept to analogous disaster issues, such as

whether Japanese communities should protect themselves against tsunamis using expensive seawalls (http://www.npr.org/blogs/parallels/2014/03/11/288691168/in-tsunamis-wake-fierce-debate-over-japans-great-wall) that cut them off from the coast or via warnings and evacuations [*Craft*, 2014].

How Much Mitigation Is Too Much?

To explore how much mitigation is enough, we considered the costs and benefits of strategies for dealing with home fires. Because fires are more common than natural disasters, students have some sense of the odds and costs involved. We considered options including relying on the fire department and insurance, a monitored alarm, and a fire-suppressing sprinkler system. More expensive strategies offer additional benefits, so the question is to how to decide which makes the most sense.

The more a community spends on mitigation, the better off it may be in the future, but the higher the cost is now.

We generalized this approach to natural hazard mitigation. The more a community spends on mitigation, the better off it may be in the future, but the higher the cost is now (http://www.earth.northwestern.edu/people/seth/research/eqrec.html). Although a community's first instinct might be to protect itself as much as possible, the community has finite resources. Resources used for mitigating potential hazards are not available for other purposes. Levees to reduce river flooding compete for funds with improving kindergartens. Money spent making schools earthquake resistant cannot be used to hire teachers.

Different Societies, Different Choices

Other discussions involved floods, the leading cause of natural disaster deaths worldwide [*Doocy et al.*, 2013]. We watched videos of the disastrous floods (http://www.nytimes.com/2013/06/07/world/europe/in-flooded-areas-of-europe-familiar-feelings-and-new-questions.html) that covered much of central Europe in 2013 and asked why Germany's mitigation measures were less effective than neighboring Holland's [*Eddy*, 2013].

(https://eos.org/wp-content/uploads/2015/03/isarclass0_embed-3_Web.jpg?ad8626)

University of Munich class discusses flood issues at the Isar River. Credit: Anke Friedrich

The class suggested societal differences. Germany treats flooding as a state problem, whereas Holland considers it a national problem [*Shorto*, 2014]. Moreover, the Dutch accept inconveniences associated with flood protection with much less opposition, the class agreed.

We discussed news reports showing that nominally 100-year floods are becoming common because of building on flood plains and shifting rainfall due to climate change. We also discussed time-independent and time-dependent probability models for floods, hurricanes, and earthquakes.

We extended this discussion on a field trip along the floodplain of the Isar River, asking whether Germany should have national hazard insurance. Geoscience students focused on the fact that such insurance (http://www.nytimes.com/2013/08/29/opinion/the-new-flood-insurance-disaster.html) makes society subsidize people (http://www.nytimes.com/2012/11/29/opinion/end-federal-flood-insurance.html) who build in dangerous places like flood plains, where it is better not to build. In contrast, students in humanities and law focused on society's obligation to citizens and favored providing insurance (http://www.nytimes.com/2014/01/31/us/politics/senate-passes-bill-to-delay-spike-in-flood-insurance-rates.html) to help people even when they acted unwisely.

Safety, but at What Cost?

Our final question was, “If you were a student in Los Angeles, how much more would you pay to live in an earthquake-safe building?” Most students decided that they would pay no more than $10/month.

This provided insight into the decades-long debate about strengthening unsafe buildings [*Nagourney*, 2013]. Because many tenants would not or could not pay more for safety, landlords could not pay the high cost of retrofits and still stay in business.

Although the whole community would benefit from buildings designed to not collapse during earthquakes, only landlords and their tenants would bear the costs. We also discussed the costs and benefits of retrofitting or demolishing the buildings and—if the community decided to—how to pay for it.

Lessons Learned

Judging by students’ feedback, the class went well. From their experiences, students learned the need for interdisciplinary thinking about these issues and that because of uncertainties and sociocultural factors, no unique or right strategies exist for any community, much less all communities. However, students agreed that there may be ways to seek robust policies that give sensible results, given the uncertainties.

We sensed interest among students to move beyond a simple “disasters are bad” view to a more sophisticated and nuanced view of the complexities of making sensible policies given the limits of our knowledge and resources. Given that, we encourage instructors to consider approaches similar to this course, either by adding material to existing natural hazards classes or by developing hazard policy classes. Classes like these seem to lead to more interested and informed students and—in time—may help produce more natural hazard scientists.

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