Natural Disasters as a Unifying Theme for an Interdisciplinary Science Course

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ABSTRACT

The subject of natural disasters offers a rich assortment of topics that can be selectively used by instructors to tailor-make a course for their unique populations of students. There is a large reservoir of student questions about active Earth processes. For science teachers who wish to convey the nature of scientific inquiry using unanswered questions of interest to their students, natural disasters present wonderful pedagogical opportunities.

Keywords: Earth science – teaching and curriculum; education – undergraduate; natural disasters.

LISBON, PORTUGAL, 1 NOVEMBER 1755

At daybreak that eventful morning, Lisbon was home to 275,000 people plus the travelers and sailors always found in a busy port. By evening, those remaining included clerics administering last rites to the dying, looters scavenging valuables from the rubble of collapsed buildings, and survivors frantically searching for loved ones or trying to salvage personal property before the flames got too close. Hundreds of magnificent masonry buildings that had been built to stand for centuries, if not millennia, tumbled to the ground with the initial earthquake. As some survivors fled to the hills, other less fortunate folks thronged to the wharfs on the riverfront only to be swept away by a great tsunami surging upriver from the ocean. Fires burned uncontrolled for four days. Debilitating injuries, exposure, disease, and starvation caused additional deaths in the winter months. The overall death toll? Most references cite 30,000 to 40,000 fatalities in the first few days and around 20,000 more deaths in the following months (Reid, 1914; Kendrick, 1956; Murty, 1977).

Lisbon had been one of the gems of European civilization, but the disaster indiscriminately claimed its buildings, art, cultural artifacts, commercial infrastructure, ships, and storehouses of food. The event disturbed some of the greatest thinkers of the time, for although disasters had struck other cities in the past, that was before the Age of Enlightenment. The scientific accomplishments of the seventeenth century had led many philosophers to develop a sense of confidence that Mother Nature was not capricious, but rather that there was a universal order driven by natural law and that human reason was capable of deciphering that order. Through science, particularly Newtonian science, everything was, in principle, predictable (Durant and Durant, 1965). Yet here was a devastating event with absolutely no precursors, surprising both the Newtonians and the religious throngs in the collapsing churches on that fateful All Saint’s Day.

Voltaire, in his satire Candide (1759), spun the tale of several shipwrecked travelers who washed ashore just in time to witness the Lisbon disaster, then were arrested and flogged by officers of the Inquisition who were looking for scapegoats to explain why God had chosen to punish the residents of Lisbon. Candide’s philosopher mentor, Professor Pangloss (“all tongue”) was hanged for heresy for suggesting that the earthquake had a natural rather than a supernatural cause. Officers of the Inquisition, their court reduced to rubble, apparently hoped such decisive actions would prevent future earthquakes. Professor Pangloss survived his hanging and was later reunited with Candide to continue spreading his ideas about natural order (Smollett, 1962).

The story of Candide underscores an eighteenth-century conflict in world views that survives yet today. Despite the tremendous successes of science in the last few centuries, even today’s best scientists continue their quest to better understand the large-scale, irreproducible phenomena that generate natural disasters. In natural disasters, we find a class of phenomena where scientists hold no monopoly on truth, the general public holds no monopoly on ignorance, and both groups agree that this is so. This situation provides fertile ground for classroom examinations of what science is and what it is not.

NATURAL DISASTERS AS A COURSE THEME

There is no lack of examples where the forces of Nature have swiftly and unexpectedly claimed human lives and the fruits of human labor on a large scale. Nor is there any question that natural disasters compel even the most complacent humans to sit up and notice Mother Nature. Archaeological evidence of disasters abounds in the prehistoric record. Writings about disasters go back at least as far as the biblical account of the fall of Jericho and survive in Plato’s accounts of Atlantis, and today, the media and the Internet overflow with accounts of recent disasters. A semester never passes without the forces of Nature causing major devastation somewhere in the world. Natural processes are wreaking disasters on humankind with increasing frequency as our relentless population expansion places more people in dangerous settings.

Meanwhile, disasters have been the driving force behind a considerable amount of serious scientific inquiry. The development of theoretical models for weather, earthquakes, volcanic phenomena, tsunami, epidemics,
Natural Disasters as a Unifying Theme for an Interdisciplinary Science Course

and so on, have been driven largely by historical disasters. Our governments and institutions fund those scientists who study what affects us most. If, for instance, earthquakes occurred only in Antarctica, we would see considerably less scientific research being done today on earthquakes.

As a course theme, natural disasters present the science educator with the opportunity to examine a broad variety of natural phenomena from earthquakes and volcanoes to weather, floods, and waves; from landslides to asteroid impacts and extinctions; from fire to epidemics. The broad range of disaster-wreaking processes directly impacts the lives of many students and many more are vicariously experienced as the media take us to every corner of the world. Many students arrive at college with unsatisfied curiosity about how the Earth works. There is a growing opportunity to serve ever-larger numbers of students. The many students in our natural-disasters courses allow us to expand their horizons and examine the epistemological bases of science, the interdependence of science and technology, and the interplay between science and society.

We developed our Natural Disasters courses independently at our respective institutions. Only recently did we discover that we were both teaching successful courses on this theme. Colleagues wishing to reach larger audiences may want to consider developing similar courses at their own campuses.

The Natural Disasters Course at San Diego State University

As a graduate student at the University of Texas at Austin, I (Abbott) was exposed to a rich variety of courses in the Department of Geological Sciences; the variety was extended by the Department’s requirement that students take at least five graduate courses in other departments. As a result, I experienced soil mechanics and hydrology in Civil Engineering, reservoir analysis in Petroleum Engineering, and plant ecology in Botany. One of the consequences of taking a breadth of graduate courses was a profound appreciation for the value of crossing discipline boundaries and understanding principles in related fields.

The Environmental Geology Course. After joining the faculty at San Diego State University, Bill Ganus and I initiated an Environmental Geology course with the specific intent of involving students in an interdisciplinary understanding of the natural world around them and examining how humans interact with the Earth in both positive and negative ways. The course enjoyed middling success during its eleven-year run, but academic-year enrollment totals never exceeded 100 students despite the relevant topics and the availability of fine textbooks.

The Name Change. In a conversation with Tom Rockwell about the Environmental Geology course, we both noted how the natural disasters topics such as earthquakes and volcanoes always aroused greater student interest during the semester than did environmental topics such as ground-water pollution, air quality, and landfill siting. I submitted the required SDSU paperwork for a course name change from Environmental Geology to Natural Disasters but did not change the course description or textbook, and zero publicity accompanied the name change. Nonetheless, in the first year of offering Natural Disasters, enough students reading the fine print of semester course offerings discovered the Natural Disasters listing and signed up, swelling its enrollment 470 percent over what we had in Environmental Geology.

The Natural Disasters Course. What’s in a name? A Shakespearean question worthy of prolonged discussion, but at SDSU, Natural Disasters as a course name is magic. Look at the graph showing the increasing enrollments in the Natural Disasters course (Figure 1). The up-and-down fluctuations in the late 1980s to early 1990s reflect instructor and room availability, not student demand. The significant fact is that every Natural Disasters section offered fills its room capacity. In 1993, a new 300-seat auditorium was completed at SDSU; we obtained a Tuesday-Thursday 9:30 a.m. slot for a Natural Disasters class which promptly over-enrolled the auditorium capacity. A year later we were able to add a Tuesday-Thursday 12:30 p.m. offering in the auditorium which filled quickly; two years later we were awarded the Wednesday evening time slot which also overfilled. With student interest at such a high level, I felt motivated to write a textbook entitled Natural Disasters (Abbott, 1996).

Does the high rate of enrollment growth in Natural Disasters reflect university growth? No. Inspection of Figure 1 shows that the greatest growth occurred during California’s recent recession, when SDSU enrollment declined significantly.

Is the high enrollment due to restricted choices for students? No. Students must pick one natural-science course for their upper-division, general-education requirement, but they may select from 30 course titles from among ten departments. Natural Disasters is enrolling 3,000 students per year yet is not satisfying demand even though courses available in other departments include such intriguing titles as Biology of Sex, Origin of Life, Evolution, The Oceans, Dinosaurs, Confronting AIDS, and other interesting topics.

Why is our Natural Disasters course so successful? I suspect that it is partly due to the life experiences of California students subjected to events such as the 18 October 1989 Loma Prieta earthquake in the San Francisco Bay area and the 17 January 1994 Northridge earthquake in the Los Angeles area. These dramatic natural events filled the minds of school kids with questions they are eager to answer in college. In San Diego, we have helped build course interest by making frequent appearances on all four local television news programs during which we discuss natural events and disasters and thus help sell the Natural Disasters class. In a broader sense, every region has its active Earth processes that cause disasters for humans. These events fill students everywhere with questions that can be answered and/or addressed in college classes.
Teaching the Natural Disasters Class. As student interest has grown, those of us who teach the Natural Disasters class spend ever more time discussing and sharing teaching strategies that work in a large auditorium setting. We have built demonstration machines (for example, for seismic waves, tornadoes, liquefaction, and strength of buildings) with more devices planned. We discuss techniques that actively involve students during the lecture period. Our new auditorium has technological toys such as remote-controlled carrousel projectors, a wireless microphone system, and a ceiling-mounted projector used to transmit images from a VCR, a 3-D visual presenter (camera), and a Power Mac 7100 computer.

My classroom approach is to engage the so-called short attention span of MTV-generation students with a variety of media during each lecture. I arrive 15 minutes before class to turn on and set up all the electronic equipment and to write in chalk on the blackboard a list of key concepts and textbook review questions to be learned from the day’s lecture. When the clock reaches starting time, I begin an organized, coherent lecture, but the presentation is seemingly broken up due to a succession of media presentations. A representative lecture might follow this sequence: 1) initial lecture presents an overview of the day’s topic designed to arouse student interest; 2) while lecturing, the movie screen is lowered, the lights are dimmed, and an Internet image is projected on the screen; 3) I ask the class a couple of questions that are answerable by studying the Internet image and have them informally discuss answers among themselves, and then 3a) I coordinate an overall understanding involving student-volunteered answers; 4) the lights are turned back on, the screen is raised, and I lecture while drawing old-fashioned, color chalk illustrations on the blackboard; 5) the screen is then lowered again and lights are dimmed (while I’m still lecturing), and an eight- to ten-minute-long segment of a NOVA video is projected via the VCR; and finally, 6) the lights are turned back on, the screen is raised, and I discuss some important philosophic points relevant to the day’s topic using semi-dramatic oratory. One of the ways I “measure” the success of the day’s presentation is by student feet. On my best days, not a single student walks out before the seventy-five-minute-long lecture is concluded.

I go to extra lengths to encourage students not to be intimidated by the large crowd and to raise questions at any time. I impress upon them that I appreciate all questions and comments, and I never embarrass any questioner. If a student question is a bit off the mark, I reword it slightly, answer it enthusiastically, and thank the student for asking the question.

I confess to being somewhat intimidated by an audience of 300 students in a spacious, two-story auditorium. I have always operated much like Levy (1997) in learning the majority of names in a 100-student class and then using that knowledge to involve the students in the topics being discussed. But...
in the switch from a 100-student classroom to a 300-student auditorium, some fundamental and overwhelming change occurred. Now I cannot even recognize the majority of faces, much less learn their names. So, how does one involve the students in this impersonal setting? Macdonald and Korinek (1995) have described their successful “Think-Pair-Share” style for actively involving students in cooperative learning in a 100-student classroom. Tewksbury (1995) explained her “jigsaw” technique for involving students in their own learning. But a 300-student audience has so far intimidated me from trying these intriguing approaches.

I find that informal approximations of the involved-learning styles of Macdonald and Korinek and Tewksbury also work effectively. During every lecture, I pause to pose questions: for example, how do you prepare your house when you receive a hurricane warning versus a tornado warning? Do you prepare the same way? If you prepare differently, what are the different preparations and why are they different? Then I ask the class to discuss the questions among themselves. The noise level in the class jumps instantly: a dull roar of animated sound fills the auditorium as spirited discussions occur among groups of two, three, four, or more students. At the first lessening of the noise level, I use various techniques to select students to respond. For example, Kevin Robinson taught me the value of throwing a Nerf (sploon) football into the crowd: whoever catches it answers the question. Students throughout the auditorium are eager to catch the ball and answer the questions. After these questions are discussed, I’ll pose a follow-on question: for example, how does preparing your house for an earthquake differ from the preparations before hurricanes and tornadoes? The students not only like being involved in the thought and discussion process, but when it is done they are invigorated and reader for the next lecture topics to be considered.

I want the students to be at the lectures, to be involved with them, and to enhance and/or develop their interest in scientific understanding and thought processes. We live in a time dominated by science and technology, yet many people are turned off by science, including many of our professorial colleagues who should behave more intellectually and professionally. Because natural disasters are part of each student’s life experience, we catch students with a real interest in specific scientific topics. The trick then is to instill in them some understanding of how the Earth works and to fill them with a personal enthusiasm and desire for learning that they will carry through their lifetime.

Overall, the structure of the SDSU Natural Disasters course is rather conventional. Besides the classroom experience and textbook study, each student must pass three exams and write an original essay using the most polished English he/she can muster. The students are also sent on Web Quests to seek information using the Internet. We do not curry student favor through easy grading policies, and, in fact, we make a concerted effort to keep our course grades near the all-University average.

One last practical note about the value of the SDSU Natural Disasters class. In the Department of Geological Sciences at San Diego State University, the general-education student enrollment in Natural Disasters exceeds the combined enrollment from all of our graduate and undergraduate major programs plus all of our other general-education courses. In the California State University system, state revenue is largely doled out on the basis of student enrollment with one student being as important as another, no matter whether that one student is sitting in a 300-seat auditorium or in one of four seats in a graduate seminar. Thus, in a very real sense, the Natural Disasters course is the prime supporter of our geological sciences program. This high enrollment, Natural Disasters-based model may be of economic value to other geological sciences departments in need of increased enrollments and institutional support.

The Natural Disasters Course at Pennsylvania College of Technology

Since 1992, I (Zebrowski) have taught a Natural Disasters course in an institutional environment somewhat different from that at SDSU. Pennsylvania College of Technology is an affiliate of the Pennsylvania State University but with a separate campus and a separate curriculum. We serve about 5,000 students, one-third of whom are enrolled in baccalaureate degree programs. In 1991, PCT adopted a set of core requirements for bachelor’s degrees that includes a minimum of seven credits in the natural sciences. The same core also requires that students complete one designated Science, Technology, and Society course (STS). With these changes in the core curriculum, we experienced a predictable increase in demand for science courses. Virtually all of this increase came from students in non-science degree programs, for example, business, pre-law, culinary arts, and graphic communications.

Development of the Natural Disasters Course. Clearly, Pennsylvanians are at little risk from the dramatic natural upheavals of earthquakes, hurricanes, volcanoes, or tsunami. Even so, I’d noticed many years ago that students in my physics courses are always intrigued by those large-scale natural phenomena that wreak havoc with the fruits of human love and labor. I’d already made it a practice to include earthquakes and tsunami when treating wave phenomena, tropical cyclones and floods when discussing fluid dynamics, and topics like pyroclastic flows and the killer lakes of Cameroon when teaching thermodynamics. Meanwhile, in my astronomy course,
asteroid impacts and mass extinctions have always captured a great deal of student interest.

Teaching the Natural Disasters Class. I’ve written my own book on the subject (Zebrowski, 1997), and I follow its sequence of topics. As with Abbott at SDSU, I vary my presentation format between audiovisual materials, demonstrations, lectures, and discussions. When a disaster strikes somewhere in the world (and this has happened each time I’ve taught the course), we follow and discuss the news media and Internet sources as the information unfolds. We also engage in a few hands-on activities, for example, exploring resonant vibrations and measuring strengths of materials. There is no way to run out of substantive material, and I’ve always ended the semester wishing that there were more time to cover other aspects of the subject.

One challenge in teaching a science course on natural disasters is to keep students from straying so far into the human interest aspects that they begin to overlook the science. To help keep everyone on track, I hand out several homework assignments that require basic computations and interpretations of stress/strain, wave propagation, epidemiology, hurricane tracking, signal/noise ratios, and other relevant quantitative concepts. I also require the students to find, photocopy, and read 16 pertinent articles during the semester. The students must cite at least six of these articles in their term paper which compares and contrasts two natural disasters. There is also a mid-term exam, a final exam, and a ten-minute oral presentation to the class on their case-study comparison of two disasters.

SHOULD YOUR DEPARTMENT OFFER A NATURAL DISASTERS COURSE?

Our independent experiences at two quite different institutions suggest that the success of a Natural Disasters course does not depend on geographical location, size of the institution, size of the lecture section, or other circumstantial factors. The course topics seem to attract students on their own merits.

Instructional resources are plentiful. Specific websites are easily accessed through standard search engines. Videotapes are available from credible producers including the National Geographic Society, PBS/Nova, and the Discovery Channel. Most college libraries already catalog numerous books dealing with natural disasters. A considerable amount of relevant demonstration equipment, maps, globes, and specimens is already available in most universities.

The instructor, meanwhile, must always climb his/her own learning curve in teaching a new course, and the challenge is greater if the course is interdisciplinary. No one can teach a Natural Disasters course authoritatively. We all have our pockets of ignorance, and if we think we don’t, Mother Nature will quickly correct us. The success of a good natural disasters course lies partly in the fact that the instructor does not claim to be the ultimate authority on all there is to know but instead emphasizes that great mysteries remain. Science, after all, is driven to remove ignorance. In fields where everything is already known, there can be no science. The mature student finds this concept to be liberating. The instructor’s responsibility becomes one of walking the thin line between what is known with reasonable assurance (and holding the student responsible for demonstrating understanding at this level) and entering the universe of questions remaining to be answered with knowledge of how to proceed using scientific thought processes.

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Pat Abbott earned a PhD degree in geology at the University of Texas at Austin. He is a Professor of Geology at San Diego State University emphasizing sedimentology and Mesozoic/Cenozoic geologic history of southwestern North America. His interest in the interface between geology and human kind has led to many public education opportunities particularly via natural disasters.

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FIGURE CAPTION
Figure 1. Academic year enrollment totals for fall and spring semesters at San Diego State University. Steady-state enrollments in Environmental Geology leaped upward following the course name change to Natural Disasters. All Natural Disasters classes fill to capacity; the fluctuations in growth trend are due to room and instructor availability.