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Finalist Essay

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Surf Science and the Language of Middle School

One of my favorite images is that of Farley Mowat in the early pages of his autobiography, *Never Cry Wolf*. Mowat is a timid biologist who naively accepts a research position studying wolves in the arctic. Not fully understanding the terms of his contract until arriving at his new post, he is left running in desperation after the plane that has just abandoned him on the frozen tundra, alone and horrified as the plane shrinks into a speck on the horizon. The wolves wait.

In all honesty, this is the image that comes to mind when I think back to my first days as a middle-school science teacher. Having left a comfortable teaching position at the university, I arrived with apprehension that soon grew into genuine terror. My new students were mysterious to me. They looked like teens. They acted like kids. They thought they were adults. All of them were taller than me. And, not unlike the wolves, middle schoolers had a scary reputation. At once, my first goal became not to teach them science but rather to understand and communicate with them. Without the latter, the former would be impossible.

It soon became apparent that middle-school students, in addition to being delightful people with keen senses of humor, like things that are extreme. Gross things, loud things, and shocking things. Anything that bites, stings, explodes, moves fast, or smells bad. Because I believe that students learn better when they are interested in what they are studying, this simple discovery eventually became the basis for my entire middle-school curriculum. Tossing textbooks aside, I developed units such as The Chemistry and Physics of Fireworks, Venomous Creatures, Mad Cow Disease, and Crime Lab Science. I would communicate basic scientific principles to them through their own language, hoping to capture their attention long enough to teach them some of my own.

Late fall in our town of Santa Cruz, California means one thing to many teens: the surf is up. For my seventh- and eighth-grade students, it also means that it is the season for our Physics of Waves and Surfing unit. We have the great fortune to have our school located on the cliffs above a world-class surf break. The wealth of physics demonstrated by a surfer riding an ocean wave is stunning—energy, momentum, force, acceleration, balance, buoyancy, and wave mechanics—all put together into an elegant display that takes place daily just outside our classroom door. My course is designed to make full use of this spectacular resource, while presenting scientific principles in the context of an activity that is relevant and interesting to my students.

One of the basic principles covered in this unit is that the location and shape of the breaking waves

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that they ride are determined by the bathymetry of the sea floor. Specifically, steep rises in the sea floor cause a swell to break, and the steepness of the slope determines the profile of the breaking wave. But instead of simply reporting this information to my students, I chose to let them discover this principle themselves. I divided my classes into groups of three and presented them with a challenge. Each group was given a 4 foot by 1 foot plastic tray, a large tub of gravel, a bucket of water, and a plastic paddle. The challenge was to create waves that break in their tray. They were instructed to use the plastic paddle to push water forward at one end of the tray, creating swell. The rest was left up to them.

They used their gravel to build islands, atolls, channels, and beaches. After discussions, arguments, and lots of noise and splashing, every group eventually achieved their goal. My students recorded their observations during this activity by drawing a diagram of one setup that did not result in breaking waves. Once they managed to create breaking waves, they were to draw the successful setup and then make comparisons between the two.

The class then visited each successful setup, as we gathered around every table to hear the students describe their creation and proudly demonstrate their breaking waves. After we dried off, I led the students in a group discussion of what worked and what didn't. As they described the physical features of their setups, I added each to a two-column list on the board under the heading of either "breaking waves" or "no breaking waves." Once the list was complete, their task was to determine which physical features had caused the waves to break. Through a lively discussion, they came to the conclusion that the waves broke above steeply sloped gravel formations beneath the water.

During the next class, we built upon their discovery by taking a closer look at how ocean waves behave as they break. I briefly described the three possible profiles of breaking waves: spilling, plunging, and surging. I then grouped the students into pairs, handed each a clipboard, and took them out for a walk to the cliffs. My first goal for this activity was to give them practice observing and identifying each type of wave so that they could do so accurately.

As students observed waves breaking, I was able to point out the features that distinguish each type of wave. Each group kept a tally of wave types over a 20-minute period. When we returned to class, each group used their tallies to calculate the percentage of each type of wave observed. We then pooled our data and calculated the class average for the percentages of each type of wave. This information was added to a large data table on the wall in our classroom. We now make weekly trips to our wave-watching spot, repeating this activity each time. Our goal is to chart the waves throughout the school year to determine whether wave profiles change with the seasons. We will use this information to support our studies of the impact of North Pacific storms on the quality of surfing waves in Santa Cruz.

While there are great benefits to living on the coast of California, the risk of tsunamis presents a challenge to our community. I used this issue as an opportunity to show my students how science can be applied to develop community safety plans and

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to further engage them in the class by asking them to help make an important decision for our school. The county of Santa Cruz issued our school with a tsunami inundation map and a destination to which all students should be walked in the event of a tsunami. However, the specific route that we should walk was not included in these evacuation plans. I decided to have my seventh and eighth graders submit a plan suggesting what our evacuation route should be.

After studying the basic features of tsunamis, my students were given a tsunami inundation map and a road map of our town. They began by identifying all possible routes to the destination. We then had a group discussion of the features that a good evacuation route should have. In this process, they were asked to take into account the fact that our school has 250 students between the ages of 5 and 14. Through discussions, they identified a list of factors that we should consider, including the time it takes to walk the route, proximity to the coastline, the presence of sidewalks, and extra challenges such as busy streets to cross. Each of my three science classes chose a different route, and we then walked the routes with stopwatches and observant minds.

When we returned to school, students were eager to share their perceptions of the route. Middle-school students are notoriously self-centered, and it is a rare moment that they are able to step outside themselves and see a situation from another's perspective. This discussion was one of those moments. Our seventh and eighth graders are quite protective of our kindergarteners, and this was reflected in the maturity of their discussion of this issue. As a group, the students made lists of the pros and cons of the route, and used these to determine whether the route could be recommended or not. I then presented the data from all three routes to each class, and they agreed on one route as the best choice. This information was written up by several students, signed by all, and presented to the head of school as their final recommendation for a school-wide evacuation route.

This morning, I arrived at school to find a surfboard leaning against my classroom door. As I gazed around for the owner, I heard bits of conversation rising from behind the lockers. "So, we're surfing at Steamer's instead of Cowell's, right?" "Yeah, dude, they're plunging at Steamer's." "I know, and they're only spilling at Cowell's." "And dude, did you check out the awesome refraction?" I grinned to myself as I unlocked my door and moved the surfboard aside. Perhaps my language was indeed becoming part of theirs.