The role of scientific research in political debates: Does fluoridated drinking water lower IQ?

Lately I have been thinking about the role of science in political debates. I am from Kansas, so news from that state interests me. During last year's legislative session several bills that involved claims about scientific evidence grabbed the media's attention. In each case, proponents of a bill claimed that the bill was supported by science, and opponents of the bill claimed that either the "science" was not science or the studies were misinterpreted or misapplied. I decided to take one of these issues and look at some of the science.

Kansas House Bill 2372

During the 2013 legislative session, House bill 2372 was introduced by Representative Steve Brunk on behalf of a Mark Gietzen. The bill was assigned to the Committee on Health and Human Services and did not move out of committee, but it did get attention for what it would require. The bill states that *"All Kansas cities and other local governmental units providing water service that artificially fluoridate their community drinking water must notify the consumers of that treated water, that* ***the latest science confirms that ingested fluoride lowers the I.Q. in children."*** That is a rather alarming claim. And a serious one. The evidence cited to support this claim is a paper published in October 2012 that has become known as The Harvard IQ study.

The Harvard IQ study

Here is a quick summary of the paper:

Methods: This paper is a meta-analysis of published studies that compared scores on intelligence tests for children from areas with high levels of naturally occurring fluoride and children from nearby reference populations with low levels of fluoride. Most studies used fluoride concentrations in drinking water as an assessment to identify the exposed and reference populations, but some studies used the burning of high-fluoride coal or the prevalence of enamel fluorosis (staining of teeth due to high levels of fluoride; these stains are white in mild cases and brown in severe cases). The meta-analysis included twenty-seven studies, with two conducted in Iran and the rest in China. Many of the papers describing these previous studies had been published only in Chinese, limiting their availability to most researchers.

Conclusions: Children from the high-fluoride regions had slightly lower IQ scores than children from reference regions, and this effect was fairly consistent across studies.

Authors and affiliations: Anna L. Choi is from the Harvard School of Public Health; Guiffan Sun and Ying Zhang are from China Medical University, and Philippe Grandjean is affiliated with both Harvard School of Public Health and the University of Southern Denmark.

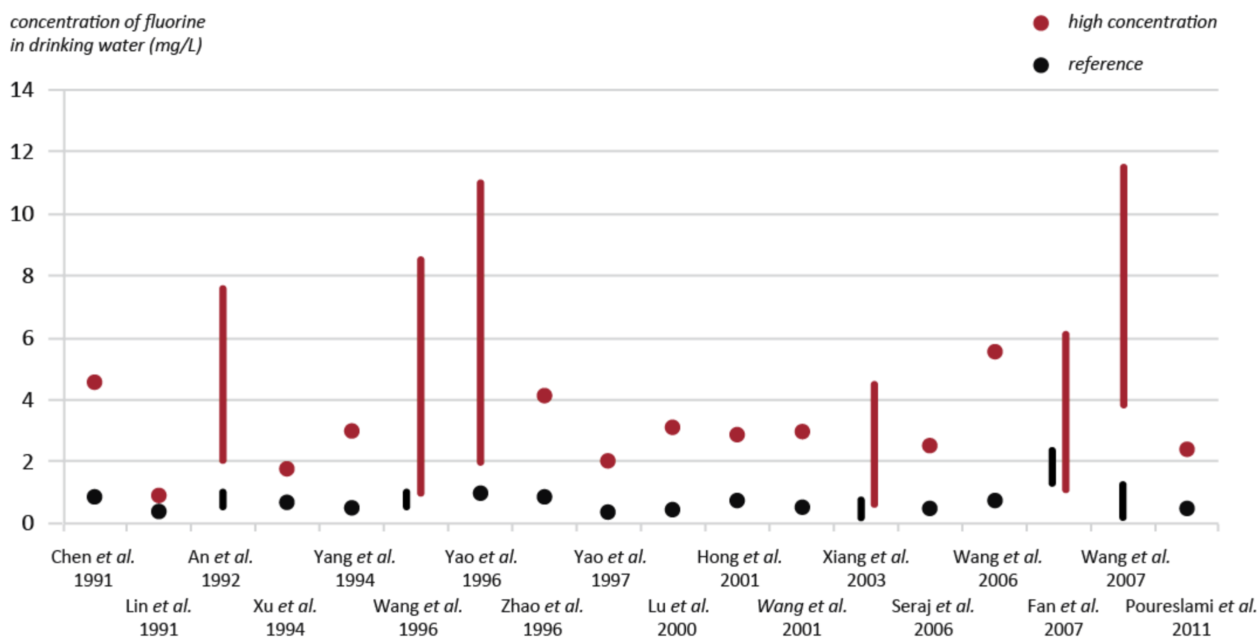
Journal: *Environmental Health Perspectives* is a peer-reviewed open-access publication supported by National Institute of Environmental Health Sciences, National Institutes of Health, and U.S. Department of Health and Human Services.

Citation: Choi AL, Sun G, Zhang Y, Grandjean P. “Developmental fluoride neurotoxicity: a systematic review and meta-analysis.” *Environmental Health Perspectives* 2012 Oct; 120(10): 1362–8.

Claims about the Harvard IQ study

Supporters of Kansas House Bill 2372 point to this paper as evidence that fluoride lowers IQ and that Kansas consumers of fluoridated water should be warned (or perhaps more directly, that fluoridation of drinking water should stop). Those arguments are countered by statements that this research does not apply to Kansas because those studies involved very high levels of naturally occurring fluoride, not low levels of fluoride added to drinking water for the purpose of reducing tooth decay. I decided that I needed a better understanding of the levels of fluoride in the meta-analysis. The authors of the meta-analysis write in their discussion, “The exposed groups had access to drinking water with fluoride concentrations up to 11.5 mg/L (Wang SX et al. 2007); thus, in many cases concentrations were above the levels recommended (0.7–1.2 mg/L; DHHS) or allowed in public drinking water (4.0 mg/L; U.S. EPA) in the United States (U.S. EPA 2011).”

I wanted a better sense of these high-fluoride levels. Was 11.5 mg/L an outlier or close to typical for these studies? The paper provides a table that gives basic information about each study included in the meta-analysis—including the fluoride concentrations for the drinking water studies—but I wanted a graph. So I made one. I used lines to represent fluoride concentration for studies that characterized drinking water with ranges of fluoride, and dots for the studies that provided a single value.



The first thing I realized is that the definition of “high” fluoride concentrations varies tremendously across these studies, but the reference concentrations are nearly all under 1 mg/L. And those reference concentrations are within the range of artificial fluoridation to intended to decrease tooth decay (0.7–1.2 mg/L). So this meta-analysis does not provide evidence to conclude that the concentration of fluoride added to the water of Kansas consumers lowers the IQ of children. (It also doen’t rule out the possibility. But considering that the meta-analysis detected only a small effect on IQ scores between the high-fluoride and reference populations in these studies, it is reasonable to conclude that difference between low-fluoride and really-low-fluoride populations would be much smaller.) And it would be fair to conclude that the science was misrepresented by the supporters of this bill, and to leave the matter at that. But stopping there would be neglecting the scientific context and the social context.

The scientific context

Fluoride is a natural water contaminant in some areas of the world. I learned from a 2006 review on fluoride commissioned by the National Academy of Sciences that high concentrations cause not only enamel fluorosis, but also a bone and joint condition known as skeletal fluorosis (characterized by increased bone density and joint stiffness and pain) and is associated with an increased risk of bone fractures. There is evidence for additional effects on neurological development and endocrine function. The purpose of the 2006 report was to review the EPA's maximum-contaminant-level goal of 4 mg/L (intended to prevent adverse health effects) and the secondary-maximum-contaminant-level goal of 2 mg/L (intended to reduce the incidence of adverse cosmetic effects). The committee recommended that the maximum-contaminant-goal of 4 mg/L be lowered to reduce the rate of enamel fluorosis and bone fractures.

If fluoride is a contaminant with health effects, why is it added to drinking water? The history has been provided by the National Institute of Dental and Craniofacial Research. In 1901 dentist Frederick McKay moved from the east coast to Colorado Springs and opened a dental practice. He found that an alarmingly high number of residents had brown teeth, a condition known as Colorado Brown Stain. McKay took great interest in this, but could find no explanation for it. In 1909 he persuaded dental researcher G. V. Black to come to Colorado Springs and investigate. He determined that the brown stains formed during tooth development, because residents whose teeth emerged white remained white, and the teeth of people moving to the area remained white. He also discovered that these brown-stained teeth were quite resistant to decay. The cause remained a mystery for years, but in 1931 the link was made between towns with Colorado Brown Stain and drinking water with high levels of naturally occurring fluoride. Soon after, researchers at the National Institutes of Health determined that enamel fluorosis was rare in populations who drank water with concentrations of fluoride up to 1 mg/L, and the cases that did occur were mild. Dr. H. Trendley Dean, head of the Dental Hygiene Unit at the National Institute of Health, suggested that low levels of fluoride might help to prevent tooth decay. A water fluoridation study began in Grand Rapids, Michigan in 1945. The rate of dental caries in nearly 30,000 school children was tracked, and "[t]he caries rate among Grand Rapids children born after fluoride was added to the water supply dropped more than 60 percent." Fluoridation of drinking water has been recognized as one of the ten greatest public health achievements of the twentieth century.

There is much more to the science context of fluoride. How does fluoride actually protect against tooth decay? Do people of different ages need different amounts of fluoride? Does fluoride need to be ingested, or just applied to the surface of teeth? Do we need fluoride in both water and in toothpaste? How much fluoride is in food and beverages? (If you want to read more, I suggest starting with this article by Dan Fagin called "Second thoughts about fluoride" published in *Scientific American*.)

The social context

Questions in the scientific context are enormously important, but it is the social context of water fluoridation that fuels the debate. The argument in favor of fluoridation of a water supply is that it is a low-cost way to reduce the rate of tooth decay. It is a benefit to everyone, regardless of economic status or access to dental services. The argument against fluoridation is that it exposes people to a substance without their consent, and the effects of this substance are not completely understood. Fluoridation disregards a person's freedom to decide what they and their families should ingest, because household water filters do not remove fluoride.

Science communication

What should be the role of science communication in debates on public policy where the science is incomplete (as it always is), risk may be present but benefits may be greater, and the social context is just as important as the scientific context? How can scientists explain to the public not only the results of science, but the process of science, its power, and its limitations?

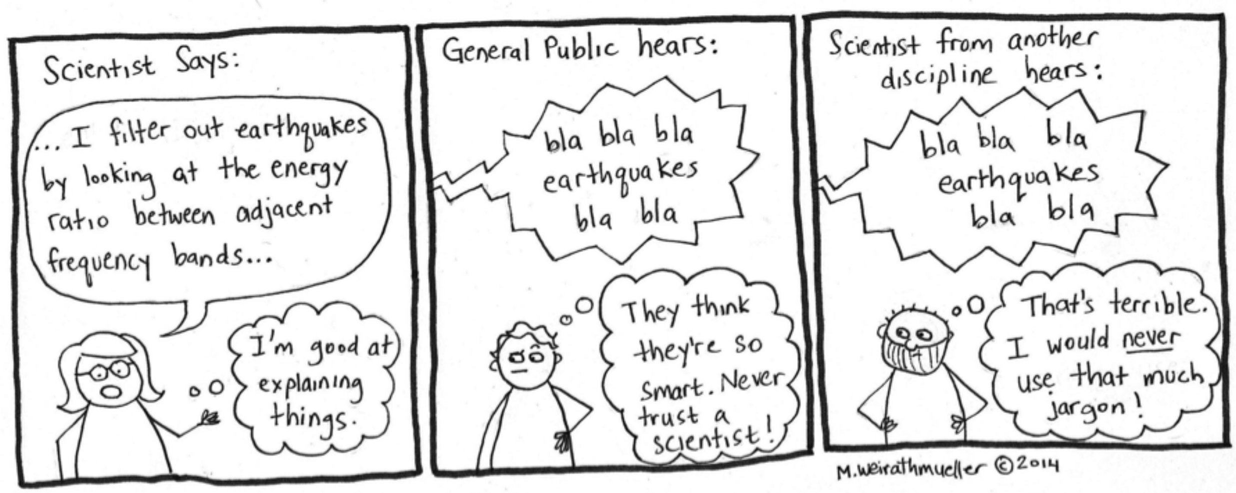
I have two ideas on strategies for science communication. The first is for scientists to not only acknowledge the social context of policy decisions, but to really understand this social context because this is the context through which the public comes to the science. The second is to be careful to avoid "scientific paternalism" (a term used by Chris Lowe in his comments responding to an article by Mike Plunkett). He writes, "…pro-fluoride argumentation often is deeply shaped by scientific paternalism and dismissal of opposition a[s] merely ignorant, and/or driven by nutty conspiracy theories… A real scientific attitude is not authoritarian. It favors education and the spread of the best current knowledge, while acknowledging that best knowledge changes."

I am ending my exploration of the topic of water fluoridation here. I have spent well over twelve hours on this, I am exhausted, and yet there are so many areas of research I did not look at. I am really wondering how our elected representative can ever make informed decisions on complex scientific-social issues. Or how voters can make informed decisions. But I know that part of the answer is that more scientists need to gain the skills necessary to communicate science to the public, and then to do it.

Student Post: Jargon be Gone!

Michelle Weirathmueller is a PhD student in the School of Oceanography at the University of Washington. She studies whale calls that show up as "noise" in earthquake records.

Last week was the first meeting of this year's Engage Science seminar. It started off a lot like many other classes – introductions all around! Except that this is the Engage Seminar, so we were instructed to avoid jargon when describing our research. I'm not gonna lie. I was feeling pretty confident that I was going to nail this exercise. I love science communication, and I know about this jargon business (or so I thought).



Finally it was my turn. My anxiety at having to speak in front of a crowd was partially suppressed as a result of my misplaced confidence in my ability to detect "science words". I cleared my throat and said, approximately, "I'm Michelle and I look at ocean bottom seismometers and I filter out the earthquakes and look for fin whales because we, you know, scientists, don't really know much about them". Huh. I had my first inkling that maybe something wasn't right. Okay, I thought. The delivery could use some work, but still, no jargon in sight. Juliana and Jessica, the instructors, informed us at that point that they'd stealthily transcribed all of our jargon words while we'd been introducing our research. And that they were going to go through the list aloud: Carbon nanotubes. Radio waves. An undefined acronym. Sure, of course. Those are clearly jargon words. And then, the moment of truth: Ocean bottom seismometer. filter. Wait. Those are *my* words! But.. but… doesn't everyone know what an ocean bottom seismometer is? And come on. Filter? Surely people will know that I mean a filter in the digital signal processing sense of the word… oh. Right, okay.

You've probably heard that saying, "one person's junk is another person's treasure", right? Well, I think that there should be another one: one persons normal-every-day language is another person's super-confusing-nonsensical gibberish. We get so used to talking to other scientists in our field that we forget which words are and are not "jargon". One of the strengths of the Engage seminar is that it brings together scientists from different disciplines. This ensures that we are remarkably efficient at recognizing each others' field-specific lingo. Jargon be gone! Now I just have to learn how to replace all those technical words with understandable, engaging language. Wish me luck!

Student Post: Science is a Different Language– Anecdotes on Avoiding Jargon

Jacquelyn Braggin is a PhD student at the University of Washington pursuing research in Microbiology. She studies how viruses can overcome the human body's natural defenses against microorganisms.

“We study herpes,” my classmates and I explained over beers to a group of people at a bar in Madison, Wisconsin. We were on a trip to my first conference sponsored by the American Society for Virology. “Everyone has herpes.”

“I don’t have herpes,” said a young man. “Definitely not.”

“Actually, have you had the chicken pox?” I asked.

“Well, yeah.”

“Chicken pox is caused by a herpesvirus called Varicella Zoster Virus. Herpesviruses stay with you forever, which is why people who have been exposed to chicken pox may get shingles later in life. So, you do have a type of herpes.”

He looked pretty freaked out.

By trying to capitalize on the shock factor of explaining that I studied a herpesvirus, I had confused my non-scientist listeners by the end of that conversation.

I’m a 6th-year graduate student in the Microbiology Ph.D. program at UW and I study human cytomegalovirus, a type of herpesvirus. When asked what I do, I try to consider the age and education of the audience. Does the person know what a virus is? If so, “what virus do you work on?” I often answer in the form of a question to see if there is recognition. “Human cytomegalovirus? CMV?” This is where I usually lose people.

The name of the virus alone is a mouthful of jargon, let alone the term “virus.” A virus is neither dead nor alive, made of proteins and nucleic acids, but this definition still falls short to non-scientists. Often, I explain viruses in the context of sickness, like a cold. Everyone has experienced the common cold. If your body is a machine, a virus is an intruder, firing all the workers and taking over to make a virus factory. Your immune system, the security, creates an inhospitable environment for virus production, thus making you feel ill. However, my research is on a molecular level. Blurting out too much detail leads to boredom. Too much novelty—“I study herpes!”—tends to distract from the original idea.

I now know that making research sound exciting to a group of scientists requires a very different skillset than crafting a simpler, well-defined account to a friend. As scientists who are constantly talking about research and new data, we often go into auto-pilot mode when asked about what we do. We speak this way with scientists we see most frequently—at meetings, in the lab, and in the hallway—which means that I not only speak with jargon specific to viruses, but even more specific to herpesviruses and a part of the immune system (the innate immune system). I know that I could probably recite an abstract from a grant proposal verbatim in my sleep, but I have to think carefully about how to respond to a non-scientist friend when asked, “what did you do today at work?” Rather than explaining and lecturing by translating science jargon into metaphors, I want to learn how to invoke curiosity in non-scientists when responding to this question.

Student Post: The Science Love Story

Natalia Woodward is finishing up her Master's degree in the School of Marine and Environmental Affairs at the University of Washington. She is studying climate change impacts on the water quality of Lake Washington and Lake Sammamish.

One of the most enjoyable aspects of this seminar is taking a break from "science brain." We all spend so much time thinking about numbers, formulas, statistics, math, data, spreadsheets…but in this seminar we get to watch TedTalks, play theater games, and think about storytelling.

Storytelling is a major theme (the major theme?) of this course. We've been talking about the story arc (introduction, complicating action, development, climax, resolution) and how it is such a familiar pattern that our brains can anticipate it. I've been noticing this myself – just watching commercials on TV, in a 20 second clip there is a buildup of tension and an anticipation of a climax or plot twist. It got me thinking about the idea of suspense and uncertainty – we don't like movies that are too predictable because they aren't exciting – there's no tension and no release.

A lot of science lectures I've been to are boring. But not because they're predictable. How can we predict the resolution of a plot that had not been set up? They're boring because there IS no plot. Just numbers, figures, statistics.

The point here is that as scientists, we live in that world of numbers. To produce robust results, to have our research withstand peer review, we need to be rational, logical, and systematic. And yet, most of us didn't decide to spend all this extra time in school living on minimum wages because we love running statistical analyses. (Although there are people that go to school for that too). Most of us decided to do this because we fell in love. We fell in love with the Milky Way, we fell in love with whale songs, we fell in love with how our hearts pump blood through our body.

My mom likes to remind me how, when I was small and it actually snowed, I would lie on the ground just staring at the snowflake crystals in the snow. Maybe I was a turbo weirdo, but I just remember being so fascinated by how they looked, how they sparkled, how their crystals all stuck together.

If we want to talk about familiar story arcs, we certainly cannot forget the love story. It's classic, timeless. We are being reminded in this class to bring our love stories back into our science, because these are stories that are universally understood. And that seems to be the main idea behind this whole seminar – get out of your head and into your heart, and connect with other people.

Student Post: Who's Your Favorite Scientist?

Andy Pickering is a graduate student in the School of Oceanography at the University of Washington. He deploys instruments in the ocean and uses the data to study giant waves thousands of meters below the surface.

In our seminar, we've been looking at how to effectively reach broad audiences (including non-scientists) with our science communication. We tend to spend most of our time entrenched in data and equations and details, which of course is important since you need something to communicate (and it's usually what we're paid for). But is all that work really useful if you can't communicate it to anyone?

Ask someone who his or her favorite physicist is. If they actually know the names of any, there's a good chance they'll say Richard Feynman. Why Feynman? Yes, he was a brilliant scientist who made many important contributions to physics and won the Nobel Prize. But he's probably better known for his Feynman lectures on physics, which were recorded in the early 1960's and are still popular today. He had a knack for connecting with people and explaining complex concepts in an intuitive way. And he was also a 'regular' guy who people could relate to on 'lower levels' (he gives advice on picking up girls at a bar in "Surely You're Joking, Mr. Feynman!").

This appeal to a large section of the public is the subject of one of our readings this week, from Randy Olson's book "Don't Be Such a Scientist." In the first chapter "Don't be so cerebral," he talks about the 4 bodily organs important for connecting with the entire audience: the head (logic and analysis), the heart (passion, emotion, sincerity), the gut (humor, intuition), and the sex organs (sex appeal). The idea is that as you move down this list, the number of people you are reaching increases. It's a good reminder that in addition to the content of your talk (the science, the results etc.), how you present it is also important. And remember that even those 'heady' scientists have hearts and enjoy humor as much as anyone else.

Student Post: Get to the Punchline!

Jane Stieber is a dentist undergoing residency training in pediatric dentistry and a graduate student in The University of Washington Schools of Dentistry and Public Health. She uses questionnaires to learn about how parents take care of their children when they have mouth or tooth pain.

Often when I meet a new person outside of my profession, they ask me the standard get-to-know-you question: “What do you do?” I usually give my standard get-to-know-me answer:

Me: “I’m training to become a pediatric dentist.”

New person: “A *what* dentist?”

Me: “A *pediatric* dentist. You know, a dentist for children.”

New person: “Oh. *Interesting.*”

And then begins the standard *new-person-has-no-idea-what-pediatric-dentistry-is-and-why-it-is-important* conversation:

New person: “A dentist who works on teeth that are going to fall out?”

Me: “Yes, that’s true. I do work on teeth that are going to fall out.”

New person: “Why would anyone want to do that?”

And here’s where the science communication comes in:

Me: “Dental caries, otherwise known as dental cavities, is the most common disease in children. Cavities are even more common than asthma.”

New person: “What?! Cavities are a *disease*?”

Me: “Yes, cavities are a bacterial disease that can be passed person-to-person, especially from mothers to their children. About one in every four preschoolers has at least one cavity.”

New person: “No way! How does that work?”

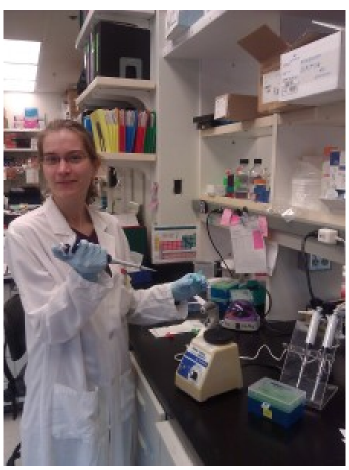
Me: “The simplest description is that bacteria metabolize sugar to produce acid which dissolves teeth. This dissolving process results in a cavity, or a hole, in the tooth. Baby teeth are no exception.”

New person: “That sounds pretty nasty. But why does it matter if baby teeth have cavities?”

And so on. The problem with my standard response to *new-person-has-no-idea-what-pediatric-dentistry-is-and-why-it-is-important* is that it takes me way too long to get to the punch line. Even once I get there, I’m still not convinced that people understand how cavities are caused, why cavities in baby teeth matter, and most importantly, that cavities are almost entirely preventable. I really don’t think people understand that it’s not a rite of passage for young children to have toothaches and abscesses and scary experiences at the dentist. Come on, people, *cavities are preventable* and, furthermore, *not every visit to the dentist has to be scary*.

But how should anyone who is not a dentist know these things? *They shouldn't*. They're not a dentist, and dentists as a whole, in my opinion, have not done a good enough job of communicating the science of cavities which could result in more people engaging in preventive behaviors. As a pediatric-dentist-to-be, I have a responsibility to improve this communication, and that's why I signed up for this course.

Student Post: Scientist vs. Stephen Colbert



Megan Cartwright is a PhD student in Toxicology at the University of Washington. She studies the bad things that could happen to our lungs if we inhale tiny, manmade fibers called carbon nanotubes, which are used in laptops and drug development.

In seminar, we're learning how to customize our talks to specific types of people in the audience. For example, my talk is about the terrible things that could happen to our lungs if we inhale carbon nanotubes–tiny, manmade fibers used in electronics and (maybe soon) cancer drugs. An audience that might come to my talk could be: Microsoft software engineers who think carbon nanotubes are awesome, because they're being used to build lighter, faster computers. Lung cancer survivors familiar with cancer caused by asbestos, another small fiber. And retired science teachers who simply love Town Hall science talks.

Each person has their own reason for coming–from curiosity about cutting-edge technology to a personal connection to lung health–and each comes with a rich background of knowledge and experiences. Important to take into account when prepping your talk, right?

Or you could not take it into account and lose your audience by swinging from one extreme (highly technical jargon) to another (unintentionally condescending descriptions of familiar things). My husband and I watched this happen when Stephen Colbert interviewed Professor Patricia Churchland (http://www.colbertnation.com/the-colbert-report-videos/432451/january-23-2014/patricia-churchland) about her new book on philosophy's relationship with neuroscience. I'm certain my audience of software engineers, lung cancer survivors, and retired science teachers would easily follow Professor Churchland's explanation of how a chemical in our brains called oxytocin is essential for mothers and babies to love each other. Unfortunately, I don't think they would all follow what she said next:

Churchland: Oxytocin is a very simple peptide that's extremely important in mammals…for example, there are prairie voles and there are montane voles. And a vole is a kind of rolly-polly rodent.

Colbert: I know what a vole is. You don't have to patronize me. [audience laughter]

By this point, I'll bet the software engineers, the lung cancer survivors, and the retired physics teachers are confused about peptides. I'll also bet that everyone is a little indignant about having 'vole' defined in such cutesy language. If Professor Churchland had reflected on who would be in Colbert's audience (educated, proficient English speakers), she could perhaps have avoided this patronizing slip-up.

Unfortunately, a bigger problem was still coming.

Colbert: How do you do that [change oxytocin in vole brains], Pat? Do you cut it out? Do you go in there and chop out bits of the prairie vole brain?

Churchland: Actually, you can do it biochemically. You can interrupt the pathways or you can prevent the receptors from being interacted with.

Whew! That's a lot of jargon–only the retired biology teachers may still be holding on. In Professor Churchland's defense, I imagine she was reacting to Colbert's question and body language, which showed exaggerated disgust and suspicion that a scientist would cut open an animal's head and take bits of brain out. I know I would have been caught off-guard.

But thanks to seminar, I have a suggestion for how Professor Churchland could respond to that question in the future.

Future Colbert: How do you do that, Pat?

Future Churchland: We give the voles a drug that stops oxytocin from working in their brains. If oxytocin doesn't work, the voles don't bond with their babies and mates.

This response respects the education and unique backgrounds of software engineers, lung cancer survivors, and retired science teachers–as well as Stephen Colbert. Who, incidentally, is more than welcome to come to my talk.

Student Post: Insights from a Cocktail-less Cocktail Party

Shelley Chestler is a second year graduate student in the Department of Earth and Space Sciences, at the University of Washington. She studies tiny earthquakes beneath the Olympic Peninsula, Washington.

Grandmothers are curious beings. Not only does mine want to know who I'm dating and what I want for my birthday, but she also wants to know what I do every day and what I'm studying

"So, Shelley," she says as we're sipping wine, waiting for Thanksgiving dinner. "Are you liking school? What exactly are you studying again? Volcanoes?"

And I say in plain words, "Well Grandma, I cross correlate waveforms to find and locate tiny, low-frequency earthquakes which may eventually help contribute to our understanding of fault mechanics."

"Oh, well isn't that nice," she replies trying to look like she understood anything that I had just said other than the word earthquakes.

Looking back, I see that what I told grandma would have been appropriate to say to a scientist looking at my poster at the American Geophysical Union conference. But why would grandma care about something as obscure as fault mechanics? Hmmm…good question.

Last week, we focused on catering our talks to our audience. I mean, it makes sense…we don't give scientific talks to ourselves! We read an excerpt from *Resonate* by Nancy Duarte. She asserts that we should treat the audience members like our heroes. We need to like and understand them before we can really connect to them. We, on the other hand, are the mentors. She specifically chooses the word "mentor." Mentors are selfless. Their two main roles are teaching, or imparting knowledge, and giving gifts that help their mentee on his or her quest. Our talks should be like a gift to our audience. They should resonate and impact their day-to-day life, if just a little bit.

So, how do we actually make our talk a gift? The key, again, is connecting to our audience. We have to step into their shoes for a second and consider what they want or need.

During class we had a little cocktail-less cocktail party. Half of us played our scientific selves and half of us played members of the community. Then we switched. I got the opportunity to step into grandma's shoes. It was not as easy as I thought, actually. While I nailed my "old lady accent," it was more difficult to consider the types of things that grandma would actually be interested in. What does she want? Who and what does she care about the most? What experiences have influenced her outlook on life? And how the heck does that affect how and what she wants to learn?

These are all questions that Duarte says a scientist should consider about each member of their audience. And given that each audience member is their own person, with their own dreams, motivations, and knowledge, this is no easy task! How do you connect to all different types of people at the same time? These are things that I had never considered before. Yes, I knew I should try to make my talk general and understandable. But connectable, too? It's going to be a challenge. But one I am excited to tackle.

Anyways as a start, I considered what I should say to grandma next time. I settled on this: “Well, grandma. Earthquakes are a serious hazard in the Pacific Northwest. Do you remember the Nisqually earthquake in 2001? I study slow earthquakes that, though they cannot be felt, they may help us to determine how big an earthquake like the one in Tohoku, Japan could be when it occurs off our west coast.”

Student Post: Science Blogging — A Veritable Troll Bridge for the Modern Age

Brooke Cassell is a graduate student in the School of Environmental and Forest Sciences at the University of Washington. When she’s not studying fire and plants, she’s tramping around the forest looking for signs of fires and identifying plants.

Fol de rol rol, who is trip trapping across my internet?! Anyone who spends any amount of time online, and who peruses the comments following most online writing, is familiar with the grumblings of those antagonistic web jerks, the “trolls”. It doesn’t matter what the article says, they’re out for blood and they’re ready to let the author know just how worthless their writing really is. As well as their belief system, intelligence, hairstyle… you get the idea. And ok, when the website in question is a major media site, a haven for celebrity gossip or a place to watch videos of adorable puppies licking delightful kittens, it’s expected that some grumpy characters might be ready to let off anonymous steam at invisible strangers (although come’on, don’t take it out on the puppy!)

But when we’re writing about things like science, and especially the parts of science that we individually find inspiring and enlightening, we might not expect inflammatory comments that seemingly come out of nowhere. To complicate matters, in science we are trained to question and to respond to questions. It is doubt and questioning that pushes science forward and keeps us from resting on our laurels. Q&A sessions following scientific talks often contain questions that get at the very fabric of our research. We can (and should!) say “I don’t know” when we really don’t, but we also work hard to think carefully about those comments and not dismiss them just because we might prefer our present point of view.

So what do you do when readers leave inflammatory questions or comments following an article or post you put your blood, sweat and tears into? How can you differentiate between an honest disagreement leading to what could be stimulating discussion and plain old trolling? In our ENGAGE seminar last week we tackled this topic. One way is to take a few minutes or hours to process the comment and decide whether it really deserves a response. Ask yourself, is this commenter presenting an alternate viewpoint or just a personal attack. If the latter, it’s ok to just leave a comment unanswered. Another way is to set up strict commenting rules on your site and follow through with moderating. If your rule is that comments must address the article’s topic and the comment simply calls the author a nasty name, then it never even needs to appear on the webpage (or can be quickly taken down by the moderator, depending on your settings).

Bottom line, while science ideas are always up for debate (it’s built in!), scientists and science communicators shouldn’t have to endure personal insults in the name of a healthy discussion. You can just say to yourself, “snip snap snout, this tale’s told out!”

Student Post: Take a Hint from Sci-Fi Films

Christina Jones is a PhD student in Pharmacology at the University of Washington Institute for Stem Cell and Regenerative Medicine. She studies a molecule that can amplify the healing abilities in a fish. She hopes to steal the fish's tricks to make useful therapies that will help humans heal better.

The other day I was trying to explain to a friend of mine what I do for research. I told her I study a fish that can heal almost any part of its body, including its spinal cord and heart. Then I went on to tell her that I want to learn from the abilities of the fish to hopefully make useful medicines that will help us heal ourselves better. This was her reply: "What can we learn from a fish? Aren't fish and humans so different that maybe you will just never figure it out." That was not the reply I was expecting. Usually when I talk to other scientists about my research they are eager to learn more. . I realized even though I told my friend about my research without using jargon, I failed to tell her *how* studying the fish can lead to human therapies. My friend's questions made me realize that I take a lot for granted about what I know about science. For instance, it is inherently obvious to me that model organisms are extremely useful for research and are similar to humans in many ways even though they might not look or act like us. However, this might not be as obvious to people who don't study other organisms.

This experience really made me wonder why the general public cares about science, and what makes people interested in science in the first place? The answer occurred to me that people like relatable stories. They enjoy hearing about science that is relevant to them and real world examples that mimic science fiction. Why is this? Science fiction is told as a story about unusual things that possibly could happen. This is also why *Star Trek* has a cult following. People are innately curious about if we are the only living beings in the universe, and *Star Trek* does an excellent job of revealing possible scenarios. People love the show so much that a lot of our technology was created based off technology in the show. I like science because when I find unexpected results, I don't have to think about it possibly happening; it is happening right in front of my eyes. So if science fiction can have such a cult following, why can't science fact? The molecule I study can make frogs grow two heads. That sounds a lot like science fiction to me. So why aren't more people lining up at my door wanting to know what's next? Besides the fact that it would be terrifying to wake up in the morning to swarms of people outside my door, the reason is simple: communication. If real scientific results were told like a science fiction novel rather than a bunch of confusing graphs and big jargon no one can understand, then people in general might be more interested.

Lately, I have been reading a lot of *National Geographic* articles and listening to *Radiolab* podcasts. Why does the general public like to read and listen to these? It is because the science is told as a story, and the authors use analogies everyone can relate to. Instead of pointing to a brain slice and explaining how the CA1 region in the ventral hippocampus sends axons to the main olfactory bulb and how this relates to memory formation (which is how I would explain it), the authors explain how researchers used a miniature meat slicer that slices the brain into sections less than 1/1000 the thickness of a human hair and soak the sections in chemicals to visualize what the brain looks like using big powerful microscopes. They also explain that we have to use mouse brains because to do the same thing with the human brain would require an amount of data equal to all the written material in all the libraries of the world. Doesn't this paint a much better picture in your head than the nitty, gritty, science-y details? Hearing science this way is not only satisfying for the general public, but also for other scientists as well.

Student Post: Stick to Your Story

Sharon Greenblum is a graduate student in the Genome Sciences department of the University of Washington. She builds computer models of how the bacteria that live in the human body interact with each other. She uses these models to figure out how different sets of bacteria keep us healthy or make us sick.

As grad students, we all wear many masks: student, scientist, consumer, collaborator.

In the Engage Seminar, we're being taught to wear new ones: storyteller, magician, artist, entertainer.

These are roles not everyone feels comfortable with. They're glimpses into another world, where there are no right answers, nothing to figure out, no A+ at the end. Where the main idea is simply to reach inside the brain (or heart! or guts!) of another human being, grab hold of something real, and occupy as much territory as you can.

Because when you tell a story, people listen. And not just listen, engage. They're right there with you, arms cross-linked, skipping along the yellow brick road. The real world gets shut off, just for a while – a few seconds, a minute, an epic two hours – and suddenly what you're saying is the most important thing in the world. You're leading them on an adventure where you call the shots, and if you're good, they'll remember that adventure, the emotions, and the bits of knowledge you sneak in long after you're done.

For example, in the last class session, we had a guest speaker. He's an astronomy professor, and every year he gives a lecture to his students about rocket propulsion. When he spoke to our class, he could have just made a bullet point list of the lessons he's learned about ways to effectively communicate complicated concepts. But instead, he turned it into a story. He had all the elements in place, and for the better part of an hour, we were a rapt audience.

setup: He thought he was a great teacher. He loved physics, loved rockets, had a beautiful, elegant proof of the 'rocket equation' to share with the next generation of budding young scientists. This was gonna be great.

conflict: Blank stares. He recounted his first lecture, how one by one, as each new line of the proof popped up on the screen, he sensed he was losing another budding mind… to boredom, to confusion, to fear, to *Angry Birds*. That first lecture still haunts his nightmares.

rising action: He's gotta face up to the facts. Maybe he went about this in completely the wrong way. Maybe it was not so much about what *he* thought was important (the thrill of those neat lines of variables transforming before the student's eyes), and more about what would resonate with the students – what they would remember. He had to start from the beginning, from something simple and universal that they would all understand.

resolution: He showed us how every year since then he's changed a piece of his presentation, sacrificing a bit of pride perhaps, but seeing light bulbs of comprehension when he finally connected. Starting with explaining rockets as different from things they were more familiar with like cars and boats, getting rid of the numbers almost completely, and making a simple moving animation of how a rocket picks up speed by throwing things off the back. It clicked. Even for me, watching that model move across the screen, it seemed like the simplest thing in the world.

As the quarter has progressed, we've been slowly metamorphosing into storytellers too. Every week we learn some new tricks. And we practice. With improv games and elevator speeches, creating hooks and keeping the tension.

Telling stories is not just a teaching tool – you learn new things about yourself in the process too. For example, I'm an overthinker. I mapped out my research as a story in storyboard form and by the end realized I was trying to cram 5 different storylines into one talk, make them all trace back to some common thread, and then tie them all up with a neat bow at the end. It was confusing for me to keep track of, but it would be a complete overload for my listeners. I would be the chef on Top Chef that tried to do quail egg soufflé three ways on top of deconstructed maple cinnamon brioche with a side of heirloom tomato puree. It sounds fancy and impressive, but most people just want '*breakfast*'.

So we're getting better. We're all working toward giving stunning talks at Town Hall this spring. Right now we're at the 'rising action' part of our story. We've recognized our weaknesses, and we know it won't be easy. But we've all signed on to the challenge, and we've got the tools to get there. The Emerald City's within sight, and I'm looking forward to a very happy ending for all of us.

Student Post: Science– hard to understand but even harder to

explain, especially when it's your science

Chelsea Kahn is a masters candidate at the School of Marine and Environmental Affairs at the University of Washington. She studies climate change and science communication, looking specifically at newspaper coverage in South Asia.

As a scientist, I know it's hard to talk about your own work – especially when you're invested in the outcome and entrenched in the details. The more dedicated researchers become to their work, the harder it is to pull themselves away from the specificities, formulas, and statistical results and think about a simpler message. Ultimately your message is what you want the audience to leave the room with; it isn't simply information, but an interpretation and understanding of information.

Senior Lecturer, Toby Smith, from the Astronomy Department here at the University of Washington learned this lesson over the course of many years. After years of teaching a course about rockets traveling to the moon, Smith realized his message was not getting across to the students. Rather than adding all the material he thought the students needed to leave the room with, he asked himself: "What's actually important? What's my message? What should I leave out?" With many years of practice, Smith answered these questions, consolidated his lecture, and landed on a clean-cut message that the students could walk away with. His message for us: **it's not actually important to share everything.**

I have been trying to put this lesson into practice. As a writing fellow for an organization that assists in marine education, outreach and research throughout Washington State, I get paired with researchers that are affiliated with the organization to write about their work. My goal is to help communicate their message. My first quarter on the job, I was working on two pieces, both about seabirds, actually dead seabirds. Prior to this gig, I never thought twice about seabirds, they never came up in my research; especially dead ones. Before interviewing and writing anything, I did my research and read everything I could get my hands on. What I found was: seabirds are important to marine ecosystems, they die for a variety of reasons and sometimes directly from human action, and we need to study and try to stop these deaths. This was going to be the message of my articles; what I thought was most important to share.

Interestingly enough, when I spoke with the researchers, this was not all they wanted to share – they wanted specific species mentioned, methods listed, and significant results shared. Scientists are passionate, but not in a way that translates easily to a broad audience. Communicators and scientists fall on very different sides of this line, what Randy Olsen would call the accuracy vs. interesting argument. I found that there needs to be a balance; you need to choose the message you want the audience to walk away with and use all of the important and supporting information for that goal. Otherwise all other details will bog down your message, and likely bore or confuse your audience. Ultimately, if you want people to think about birds, you have to talk about birds and not about non-target species in marine fisheries.

Student Post: Reunited and it feels so good– Science and Art Together Again

Emily Davis is a graduate student in the School of Aquatic and Fishery Sciences at the University of Washington. She spends her summers tromping through central Idaho streams, investigating how they recover from wildfires.

A recent NY Times interview with actor Alan Alda struck a real chord with me and got me thinking about the interaction between science and art—something we're often thinking about here at Engage. In the article, Alda describes his lifelong love of both writing/drama and science. Though the two subjects initially seemed hopelessly separate, he's now able to bring them together by teaching scientists to be better communicators. Alda says,

"I knew I had to be a writer and actor — I'd been preparing for that since I was 8. But I was curious about science and nature, too.

Unfortunately, the way things were organized, I was forced to decide between them."

Upon reading this, a series of lightbulbs exploded in my head. I think of myself as both a scientist and an artist—specifically, a writer. But until just recently, I thought of Science and Art as two rarely-intersecting universes, places *verboten* to each other, like East and West Berlin. I was one of those people who would sneak back and forth over the wall, secretly switching my allegiance between two worlds and two identities. Partially due to Engage, I've finally been able to break down the invisible barrier I'd created in my mind between these two disciplines. The division between Science and Art is a false dichotomy. Both disciplines use creativity to solve problems and depict patterns in the natural and human worlds. And both disciplines, when they're done well, rely heavily on narrative and storytelling to communicate ideas.

I've been a storyteller practically since birth. As an eight-month-old, I would give strangers the shock of their life when I greeted them in complete sentences from my stroller. As a preschooler, I'd take my arsenal of plastic toy animals and set them up around the house, muttering to myself as I created elaborate storylines that would absorb me for hours. The penchant for words continued through high school, where I attended writing camps and workshops and submitted work to teen literary magazines.

When I got to college, things got more complicated. Words themselves weren't the only thing that interested me. I became fascinated with the stories that landscape could tell. What kind of story could a gravel bar tell, the way it was covered with willow, about when the river had last scoured it, and how big the flood had been? And what kind of hidden history was inherent in the phenology and behavior and genetics of a particular stream's salmon stock? I loved these stories because they were alive, dynamic, changing in real-time, and they meant something tangible.

But in college, you have to pick a major. You have to choose, like Alan Alda felt he had to, as the educational system funnels you progressively toward narrower and narrower specialties. I agonized over this, but eventually chose to major in Biology & Environmental Studies. Luckily, I attended a liberal arts college, so I had a lot of latitude in what other courses I could take. I took nearly every creative writing course offered by the college, and all the literature courses offered by the Environmental Studies department. I used to joke that I was a closeted English major. Because I was at a liberal arts college where interdisciplinary thought was highly valued, my dual pursuits didn't seem strange. It seemed natural to simultaneously revel in the two subjects that were of most interest to me. I came to identify strongly with both: I was a Biologist, and I was also a Writer.

Once I graduated from college and was thrust rudely into the working world, my two loves seemed less and less compatible, more and more separate. By the time I started thinking about applying to grad school, I felt trapped. For three years I'd dabbled in various ecological jobs, putting off what I saw as the necessary decision between the world of storytelling and the world of science. I viewed it (wrongly, in hindsight) as a choice between my two identities. I loved ecology, but I was terrified to choose ecology, because I was convinced that as soon as I fully embraced a Scientist Identity in grad school, all my ability to write and tell stories would slough off and blow away in the wind, like a snake shedding its skin. In the Old Testament, when King Solomon offers to resolve a quarrel between two women over who is the true mother of a baby, he suggests they chop the baby in half. I felt like that baby.

I applied to grad school in ecology, got in, and immediately felt my creative identity go into hiding. Nobody in my department wanted to talk about non-technical writing, I (wrongly) assumed, so I would just squelch that urge to express things in lyrical prose. My desire to express ideas this way didn't seem like a cool ability anymore; it felt instead like a weird disease that I never talked about. I took lots of math and programming classes, which I initially found terrifying and foreign. (I can understand math in the same way I can put together a complicated Ikea home entertainment system: out of sheer necessity, slowly and methodically, and usually with a beer in hand for moral support.)

At first, I just sort of shut my eyes and muddled through, trying to pretend I was somewhere else. People talked about things in equations, but my native tongue is metaphor. I felt like an outsider, like I didn't belong there. What was a verbal person like me, a creative person, doing here? I constantly wondered if I had made the 'right' decision: to embrace the quantitative nature of Science, dutifully do good in the world through ecology, and leave my love of Art, of storytelling and sharing ideas through narrative, behind. I had built a clumsy wall in my brain dividing the two disciplines.

Yet with each additional course in programming or statistics, it got harder to ignore the fact that, even though I didn't have a natural talent for the material, it was still a fascinating tool. *Nope*, I told myself. *I'm not really a 'math person.' I'm just doing this so I can tell the ecological story*. *Soon's I tell the ecological story, I'm outta here*. *Back to words.* But the ecological story soon outpaced my ability to lie to myself about what was happening. I was….telling stories with numbers. And I was enjoying it. My desire to tell the ecological story became a Will-o-the-wisp, flickering just over here, then whispering just over there, leading me further and further down the foggy, boggy, sometimes quagmired path of math, into the tangled and dark forest of data analysis.

With math, you could take the whole life of a river, component by component, and embed it into lines of code, painting with nuanced and deft brush strokes the pushes and pulls of energy and materials through the ecosystem. I could describe the invisible, reticulate matrix of stone and current and creature in a paragraph full of adjectives, but I would never be able to capture its truly dynamic spirit in the same way I can when I model it in R. Words and numbers capture complimentary, sometimes overlapping essences of the same story.

I came to see how storytelling in science and in writing isn't necessarily different. It's just done in different languages. In science, the aim is to tell a story, as accurately as possible, about an organism or process or system of interest. You frame and build a narrative through the collection, careful analysis, and elegant presentation of data, then weave it into a believable fable. That moment when a story—however small!— rises up from those numbers: that's alchemy. That's an addictive high. It doesn't happen every day, but it happens. That search for story is the carrot dangling from the science stick; that's why it appealed to my writer's nature.

You present the story differently, of course, depending on your audience. Stories can be communicated numerically, through mathematical models. They can also be communicated verbally—orally or in written form—or visually. My natural ability leaned heavily toward verbal skills, but in becoming a biologist, I learned to code-switch into math, and appreciated the ability to tell stories in two ways.

I have been trained to count and to measure. It is a mindset not easy to unlearn, and I don't necessarily want to unlearn it. I carry a mental pair of calipers with me wherever I go. But I also want to be able to communicate the elegant quantitative storytelling I've accomplished to people who might be nervous about numbers and equations—just like I was a few years ago. I desperately wanted to be an ecologist, but I felt like an outsider because I didn't speak the language of math. Now that I do speak that language, I want to make sure that others who are potentially considering a science career don't feel like I did. I want to make the beauty of ecology apparent to people through code-switching from a good quantitative story to a good verbal and visual story.

That's where people like Alan Alda, and programs like Engage, come in. They make me unafraid to use both my creative side and my passion for science at the same time, showing me that Art and Science are actually closely intertwined. If we let them, Art and Science can enhance each other in a synergistic way. I'd previously had a very limited idea of what it meant to be a scientist, and what it meant to be an artist. But Engage has helped me expand my ideas and therefore merge my two identities. (If you still need some help expanding your ideas of what scientists are, please read this article on why Beyonce would make a good scientist.)

In Alan Alda's words, "Science and Art are two long-lost lovers, yearning to be brought together. And now I get to be a matchmaker."

I'm a scientist. I'm an artist. And when you get right down to it, these two are just different ways of asking the same questions about our world.

Elevator pitches: fresh, not canned

Preparing an elevator pitch (also known as an elevator speech) is a fundamental part of Engage training. The idea is that scientists should be able to provide a brief, "big picture" explanation of their research that can be understood by anyone and delivered anytime and anywhere. It is not easy to put together these jargon-free introductions that answer the question "What do you do?" in a way that captures someone's interest instead of sending them searching for a polite way to exit the conversation.

The topic of elevator pitches often comes up in science communication, so I was not surprised to see it mentioned in Marc Kuchner's book *Marketing for Scientists: How to Shine in Tough Times*. But what I wasn't expecting is how he frames the elevator pitch.

This book is based on the idea that scientists need to communicate how their work meets the needs of other people and organizations, and this "marketing" is the key to a productive and successful career in science. These people and organizations range from academic departments and funding agencies to members of the public and legislators, but the focus is always kept on that other person or organization and their needs. (The term *marketing* has a rather negative connotation in science, but it probably shouldn't. Marketing is explaining how our research, skills, knowledge, and ideas can meet the needs of someone else.)

Dr. Kuchner frames the elevator pitch this way in chapter 3:

Folks in business learn that the elevator pitch is not a prepared speech; rather, it's an opportunity to try to understand where your customer is coming from, and help them tell themselves a story about how your product fits in. In other words, an elevator pitch is about the positioning of the product.

For example, I'm an astronomer, and much of my work could be considered esoteric. So I often start my elevator pitch saying, "You know the Hubble Space Telescope?" Of course people know about the Hubble space telescope. Then I try to tie their knowledge of the Hubble Space Telescope to what I'm working on. For example, I might say that I'm working on a successor to the Hubble Space Telescope, a future telescope that we can use to study planets like the Earth orbiting other stars.

Wait, this shouldn't be a prepared speech? I am supposed to include questions to gauge the person's level of knowledge and interest? This is supposed to be about them, not me?

This adds a new level of complexity to a task that was already challenging. How can we prepare for these interactive elevator pitches? Do we start with a canned 30-second pitch and try to un-can it based on a particular situation? Should we write elevator pitches in the style of choose-your-own-adventure stories? Maybe the Engage class should have a "speed dating" activity in which participants do a series of one minute elevator pitches/conversations with other members of the class.

I will be starting a job search this fall, and one of my priorities is being able to confidently and clearly describe what I do and why it is important. So please ask me what I do, because I need practice explaining.

Student Post: My Dent in Human Understanding

Jesse Macadangdang is a graduate student in Bioengineering at the University of Washington. He studies how to build a small piece of heart muscle in the lab that can be used to better understand heart disease in patients.

One of my favorite ways to think about science and my own studies in grad school is drawn out succinctly here: http://matt.might.net/articles/phd-school-in-pictures/ . “The Illustrated Guide to a PhD” pretty much sums up what I know about the world. I was given a very nice, well-rounded education in elementary and high school. I learned things like adding and multiplying, the Pennsylvanian Native American tribes, the Dirty 30 grammar rules, the basics of Spanish, and even how to sew. In high school I showed a propensity for certain subjects like Math and Biology but it wasn’t until I got to college that I was really able to focus on them. As a biomedical engineer, I was learning things that really piqued my interest and made me want to know more. While this was great for me, it also started a slow process of knowledge isolation that really only intensifies as I push further with my studies in grad school.

Specialization is inevitable in society today (and in human society as a whole, really) because no one can know everything. The geniuses of our society are very often marked by their glaring lack of knowledge in areas outside their wheelhouse. Paul Erdös for example, one of the most prolific mathematicians in the 21st century, could barely care for himself and relied on others to cook and clean for him. So instead of trying to do the impossible and learn everything, we settle for either knowing a little about a lot of things, or a lot about very little (depth vs. breadth of knowledge). "Guide to a PhD" does a great job at illustrating this point. There's so much of the collective human knowledge that is left outside of a certain expertise, yet it's still very easy to get sucked into our own little worlds and forget about the big picture.

And that's not all that is surprising to me. What we're doing in our pursuit of a PhD is invariably hard. We're going up to the boundary of human knowledge and trying our darndest to make a dent. We're past the point of "right and wrong" answers and instead are asking the bigger, deeper questions of how and why. To do this you often have to engross yourself in your work, to become singularly focused on the unanswered question at hand. I see this driven focus all the time in research talks here at the UW but it often doesn't help in communicating the overall message. Researchers will give one or two opening slides about how their work is relevant to the world at large and then jump right into the nitty gritty of their thesis work, like cutting in three-quarters of the way through a movie. Almost immediately I can feel my mind racing to make connections to what I already know but often times I just get lost and end up missing the major points of the talk.

This is where the Engage class has really made an impact on me. Even as an informed scientist, I often get lost in your run-of-the-mill-science talks because I didn't connect with what was being presented. So when given the task of talking about my own research at Town Hall to the general public, I really struggled with where to begin and how to connect. I want to get people as excited as I am about my work but the most important thing to remember is to do this in a relatable manner. Therefore a lot of the specialized knowledge I gained in college and grad school really won't come in handy when trying to explain my work. Instead, I need to take people on a familiar journey, one that is almost engrained in the human psyche, with a complicating action, development, climax, and resolution. Combining the story arc with apt metaphors and avoiding jargon can go a long way in getting your message across to a wide audience.

So as I prepare for my talk, I've been peeling back the layers of my research to the point where the majority of people will have a shared knowledge base. The "Guide to a PhD" depicts this area as the centrally shared knowledge of elementary and high school. By doing so I hope to connect with my audience and pique their interest in science. Because no matter how small of a dent my PhD work may make in the whole of human knowledge, if I can successfully convey my message to the audience I will be a happy scientist.