Project Title: Arsenic Part 1: Analyzing Downeast for increase in water testing awareness. Part 2: Arsenic's effect on garden variety tardigrades.

School: Machias Memorial HS

Grade Level: 9-12

Teacher: Jim Lenke

Project Partners: I did all the work myself with no assistance of my partner. My project partner is/was William Otto from University of Maine, Machias.

Teacher Profile: My industrial career began in 1987, and in 2014 I switched over to education. My B.A. is in Chemistry, where I slowly learned my specialization was analytical instrumentation. I was given the title of Chem Department Factotum. My work and career have taken me around the world and back, although home is Chicago, IL.

I am most passionate about applying technology to improving science, both in and out of the classroom. I have several projects that I am currently working on besides arsenic: designing and building a Cubsat, and the Kleinshmidt windstorm challenge from University of Maine Composite Engineering W2 program. I absolutely love alternative energy and am always seeking new ways to invent or improve something. My interest in starting a water testing/citizen scientist program in my school was the community value. I'm most curious about the long-term effect this study will have on the students as they acquire their own properties and how they will react to arsenic as a poison. Equally interesting, as a marketeer, how successful can a program be in convincing a community to change its habits. All my years as a product developer are being put use in a single project.

Summary: My curriculum began mid-fall by introducing data analysis and CER (Claim, Evidence, Reasoning) to all of my students. All types of graphs and Venn diagrams were displayed to lay a groundwork for axis reading. Through the different units on physical science, students were always asked to graph data that they collected from experiments and example calculations. Many students had difficulty determining the size of axes and typically which variable to put where. To tackle these problems, training in Tuva software was followed using activities in designated data sets. The goal was to move students to a point where they could create and answer their own questions on any data collection. Late fall brought in all student water samples (58) followed post holidays by another set from interested faculty (12).

Chemistry unit for Freshmen is in spring, and water sample data analysis and the bioassay were to take place concurrently. Additionally, coinciding with Earth Day, the arsenic awareness campaign was going to debut with flyers and a local paper article. However, just before beginning of fourth quarter, and Chemistry, the country began isolation with students sequestered at home. Further, being overrun with public health information on particle/virus transmission was not the time to bring up arsenic. So, the decision was made to put off until later, but to ride on the coattails of heightened public health awareness. Nonetheless, the data was assembled and presented to all students and asked for meaning behind plots. Emphasis was to be on how to improve arsenic testing in our county. Approximately 75 samples were collected in our immediate area covering 18 towns and two biomes: coast and mountain.

The bioassay was to study tardigrades and the effect of arsenic on them. Tardigrades are the only living creature to successfully survive unprotected space for any length of time and brought back to full life. Found easily in moss, these specimens were to be collected, then subjected to dehydration, followed by rehydration; would arsenic tainted water immediately invade the specimen to present as complication? Unfortunately, this bioassay was not completed as classes were moved online. Regardless, over the summer this test will be undertaken by the teacher to identify problematic areas in order to have a smooth experiment for students the following year.

Project Details:

A. Classes
    1. Freshman Science - a overview of physical science:(3) class periods that contained either 12 or 18 students
    2. Chemistry - both honors and regular - that contained 12 students
    3. Total students: 60
B. Curricular items
    A. A page was added to my class website
    B. Several articles and state sites were provided
        A. https://www.sciencedirect.com/science/article/abs/pii/S0013935116301542
        B. https://bangordailynews.com/2014/06/30/news/state/how-politics-derailed-epa-science-on-arsenic-endangering-public-health-in-central-maine-and-nationwide/
        C. https://www.epa.gov/sites/production/files/2014-03/documents/a_review_of_arsenic_poisoning_and_its_effects_on_human_health_3v.pdf
        D. https://statecancerprofiles.cancer.gov/incidencerates/index.php?stateFIPS=23&cancer=001&race=00&sex=0&age=001&type=incd#results
        E. https://ehjournal.biomedcentral.com/articles/10.1186/1476-069X-13-23
        F. https://www.maine.gov/dhhs/mecdc/navtabs/data.shtml
    C. Questions posed were basic to allow for deeper investigation:
        A. Why is arsenic harmful?
        B. Where is arsenic found?
        C. Who cares about arsenic poisoning?
C. I had collaborated with a maths teacher, who was co-teaching science with me. Our goals were to: find a unifying language between maths and science; find a simplified method of teaching students graphing and calculation techniques; instill a nurturing attitude towards our community and the next generation's water needs. There were no experiments completed besides rudimentary exploration of creating known concentration solutions and identifying an unknown concentration.
D. Stipend was used to purchase water containers and packaging. Shipping of samples were transported by car.
E. Situation did not allow any guest speakers to the room this year.
F. Tuva was used extensively to answer activity questions on various cases. It was also used periodically to demonstrate a fact or relationship. Arsenic data images were supplied to students and they were to decipher for meaning and values. Tuva was a wonderful program and several students commented on how fun it was and easy to use. Almost all students preferred looking at the data as dots instead of pie, bar, line, or box plots. Somehow the ability to identify which has more is better done with dots instead of lines – huh! Who would have thought?
G. Our community meeting was to be twofold: a newspaper article and a public lecture session held at the local university auditorium. Only the newspaper article was finally put into action. The advanced students

put together their versions of mock articles as an assignment, from which were drawn ideas to form the final version. Feedback from various community members was supportive, but not extensive. Chemistry students also had to create posters that were meant to be placed around town to raise awareness. Some much better than others. Advertisement principles were discussed and employed during this 2-week activity.

Discussion:

- Students were able to learn rapidly how to ask and answer questions about data presented as dot plots. Nearly 100% of students enjoyed working on Tuva and finding answers within the data.
- I learned more about my community being an outsider. Many homes don't care about water - or a good deal of other things - and this barrier is hard to break through. Not ONE story will work for all. Organization of everything is key, because nothing ever goes smoothly; water samples get lost or turned in later, there's a fire drill the day you wanted to have an important lesson, your partner does nothing for you, etc.
- The following round will be much easier: I know the content and specifics, I know how to collect samples and return, I know how to get information into the community. The real hard part is getting samples from other houses that don't belong to my students. In order to get a better picture of arsenic levels, more data points need to be collected. It is also quite hard to get specifics about cancer rates/levels by county/city. Finally, for myself, I would reconsider the idea of having a partner. Perhaps a partner skilled in GIS would be preferential as it is data that needs to be displayed and overlapped with geologic and cancer rates.

Conclusion:

This is a magnificent project that is actually loads of fun, if things are organized ahead of time. Data collection of bioassays can be deceiving as some specimens improve while others degrade, which can send a conflicting message to the lay person. It also allowed the opportunity to begin conversations that normally wouldn't have happened in my courses: cancer, advertisement, or bioassay. As with many things in life, the closer one gets, the more detail with less answers appear on the horizon.

Acknowledgement: The work reported in this publication was supported by the National Institute of General Medical Sciences of the National Institutes of Health under Award Number R25GM129796. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.