GARDINER AREA HIGH SCHOOL

Project Title: SEPA Arsenic Study

School: Gardiner Area High School

Grade Level: 9

Teacher: Kyle Duca

Project Partners: Scott Eaton - ProVerde Labs - Portland, ME

Teacher Profile:

My name is Kyle Duca and I have been teaching at Gardiner Area High School for three years. I graduated from the University of Maine in 2013 where I studied biochemistry and abnormal psychology and the University of Southern Maine in 2016 where I received my training in education. Prior to entering education, I spent four years in various fields of research including genetic engineering, behavioral psychology, and neuropsychopharmacology. It was this experience of applied science that made me passionate about bringing real life research opportunities to my students in the classroom. When I was introduced to the idea of the All About Arsenic project, I saw it as a perfect opportunity to help my students become citizen scientists in their community. The integration of data analysis techniques and software was an added bonus as I have also striven to help students see mathematics as more than a conceptual framework to be completed in Algebra class. The combination of these factors made the All About Arsenic project a perfect fit for what I wanted my students to experience.

Summary:

Though I began the project eagerly, it proved to be harder to find student motivation than I originally anticipated. I began the study by incorporating aspects of water quality analysis into my yearlong Honors Laboratory Biology class. This included several trips to the local Cobbosseecontee stream where students collected water samples from a variety of sites to be used in our analysis. Students learned how to judge the health of a body of water through testing for excess nutrients such as nitrates and phosphates, while also understanding factors such as pH, turbidity, and dissolved oxygen. Bioassays were completed where students took the collected water samples and used them to cultivate a population of duckweed and evaluate how the data collected earlier correlated to the growth of the population. After several weeks of this nature of study, we transitioned to applying these concepts to the water supply of a human population.

Our arsenic study began in earnest when we discussed the water cycle, how groundwater can form into aquifers, and how the aquifers could transmit certain properties through the slow weathering of the rock. This is when we introduced arsenic, discussed its prevalence in northern New England, and explored the tremendous health effects it could have through chronic exposure. After being assigned the task of collecting samples of well water for the study, problems began to emerge. This is when I began to realize that the group of students I was working with lacked the intrinsic motivation I was anticipating. I had formulated the project with the idea that if I gave them a push, the students would run with it. What occurred instead was a meager three samples returned from the thirty or so originally distributed. Because I had never imagined this as a graded task, my students simply did not see the purpose in participating. I had failed to engage them.

This disappointment frustrated me and I elected to sideline the project while I considered how I could improve its execution. I determined that I would forfeit the progress I had made and instead introduce the project to my upcoming Honors Earth Science class that would start in the second semester. When the time arrived, I introduced the project in a fairly similar manner. This time, however, I could see engagement right from the beginning. We worked through a similar curriculum as mentioned before with the addition of a section on the utilization of Tuva and how to choose the right graphs for different sets of data. When tasked with collecting water samples, in an effort to hedge my bets, I made it a required grade. As a result I had a 100% return rate giving us a final total of 22 samples. In retrospect, I should have pushed the students to continue collecting but I was so happy at the time that I had participation that the thought never occurred.

Following the collection process, our samples were sent out for analysis and the data was returned. Students were divided into teams and tasked with creating an effective presentation of the data and all around effects and importance of arsenic to share with our community. Our class collectively created a rubric of required materials and set to work on constructing their displays. Each group was given approximately two weeks to complete this task and overall produced some high quality work. Due to the restrictions of the venue in which we would be doing our community presentation, one team of four was selected to represent our study and did so by sharing their research and analysis with hundreds of community members at a district showcase of student work.

Project Details:

General Details

Though the course of our project we utilized a number of resources available to us online. These ranged from EPA recommendations to data sets to health information. A sample of these resources are listed here:

- EPA Chemical Containment Rules
- Arsenic in Private Well Water FAQ
- The Effects of Too Much Arsenic in the Diet
- CDC - Arsenic
- All About Arsenic
- The Problem with Arsenic by Bruce A. Stanton, Ph.D
- Anecdata

As described in the previous section, we did take a field trip to the local stream, the Cobbosseecontee, in order to collect water samples. We used these to complete a number of labs including water quality testing and bioassays using *Lemna minor*. These labs were critical in allowing students to understand the components of what makes water healthy and to see the effects that it could have on the growth of a living organism. Engagement in these activities led to questions such as:

- What makes water healthy?
- How do levels of different nutrients/elements affect living things?
- What causes the levels of nutrients to change?
- Do different parts of the stream possess different properties? Why?

All of these questions provided the perfect segue into our focus on arsenic since they got students considering the fundamental concepts we would be exploring. They had already witnessed the impact and prevalence of other nutrients so extending these principles to arsenic was a natural continuation of the learning that had already occurred. To assist in the transition to our arsenic study, we invited our scientist partner, Scott Eaton, to introduce the project, discuss the importance of data, and help emphasize the responsibilities of a citizen science. Having a “real scientist” working with us also convinced the students that the project they were participating in was more substantial than just another thing they had to do for school. I believe that this visitation helps to explain the increased motivation of the second group of students that I attempted this project with since the first never had this guest speaker opportunity.

Tuva

Tuva proved to be an incredible tool both for the arsenic data as well as other class data sets collected through the year. The data set for Gardiner that we received was uploaded to Tuva as was the overall study set downloaded from anecdata.org. Both sets were shared with students who, after some training, were given complete liberty to play around with the visualization of the data. One group went so far as to edit and upload their own data file so that they could create unique graphs that they had imagined. Student engagement with the tool was very high and I saw the process of data analysis clicking in a way that it had not in years prior to the use of Tuva.

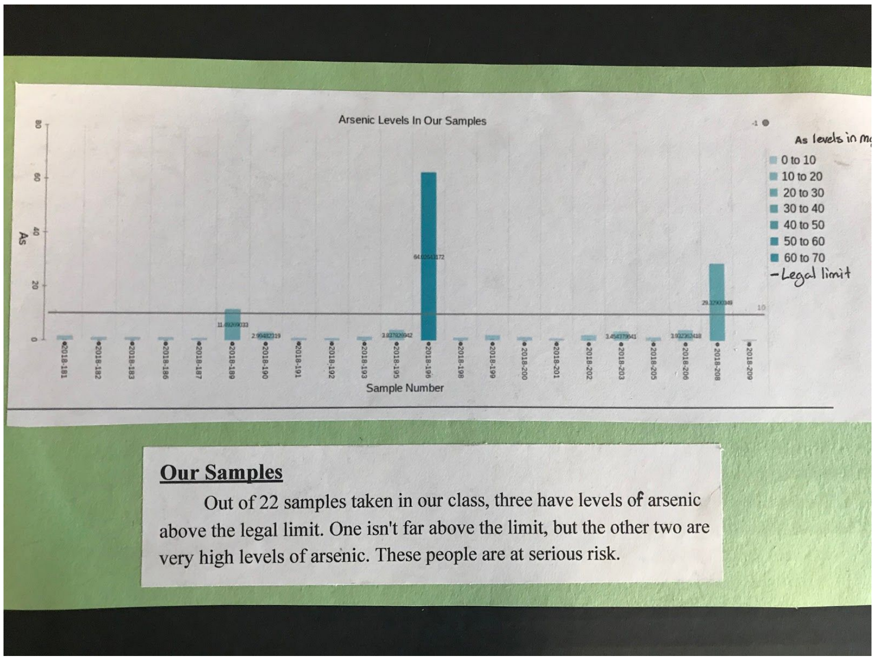
Tuva was not only used for the processing of our arsenic data, but also in another citizen science project we work on annually with Gardiner’s alewife run. Every year, students take several trips to the Cobbosseecontee stream to witness the migration of alewives from the Atlantic Ocean to their breeding grounds upstream. Unfortunately for the fish, the stream has three dams which prevent their progress and cause them to pile up in the still pools to the sides of the stream. Students collect data for the State of Maine and a local nonprofit on the demographics of the fish in the stream. This involves measuring, massing, and sexing the fish. This year, because we had access to the program, Tuva was used to give students the opportunity to analyze the data and begin to make conclusions about the nature of our alewife run as well as about the species as a whole. They were able to accomplish a number of tasks such as creating pie charts to view the overall distribution of males and females in the population and creating box plots comparing the masses of the sexes to try to determine whether there is any dimorphism. This was a very educational experience for the students and would have been far more tedious without access to the Tuva program.

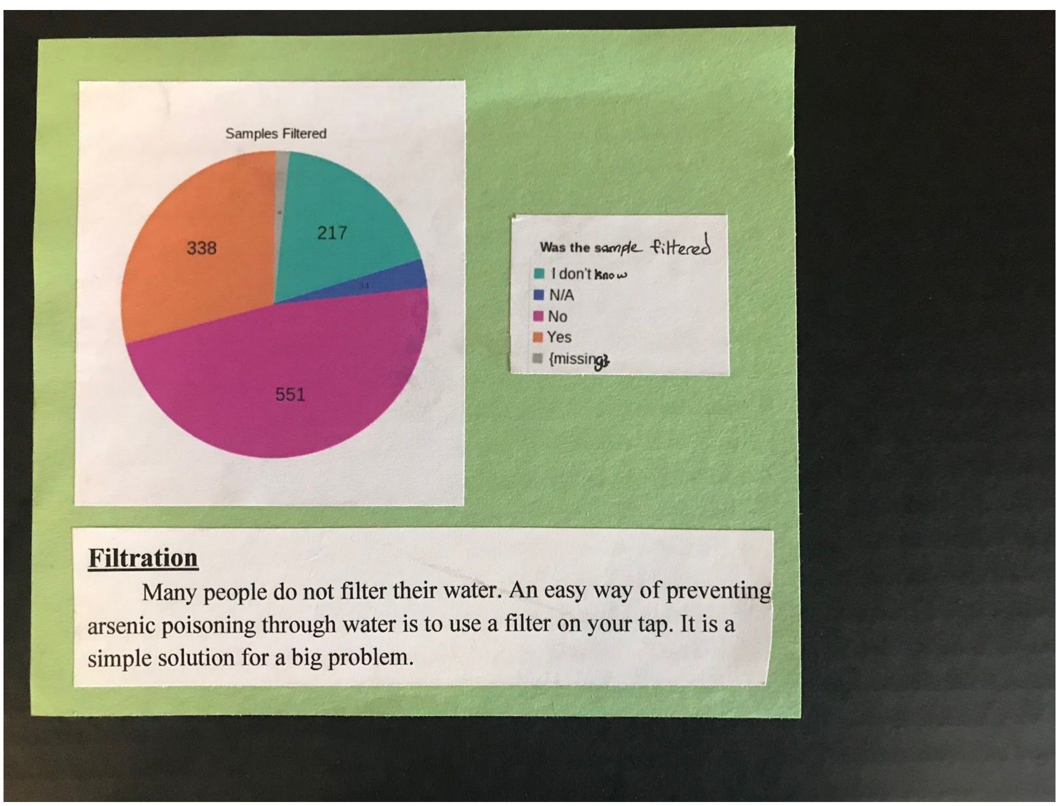
Community Meeting

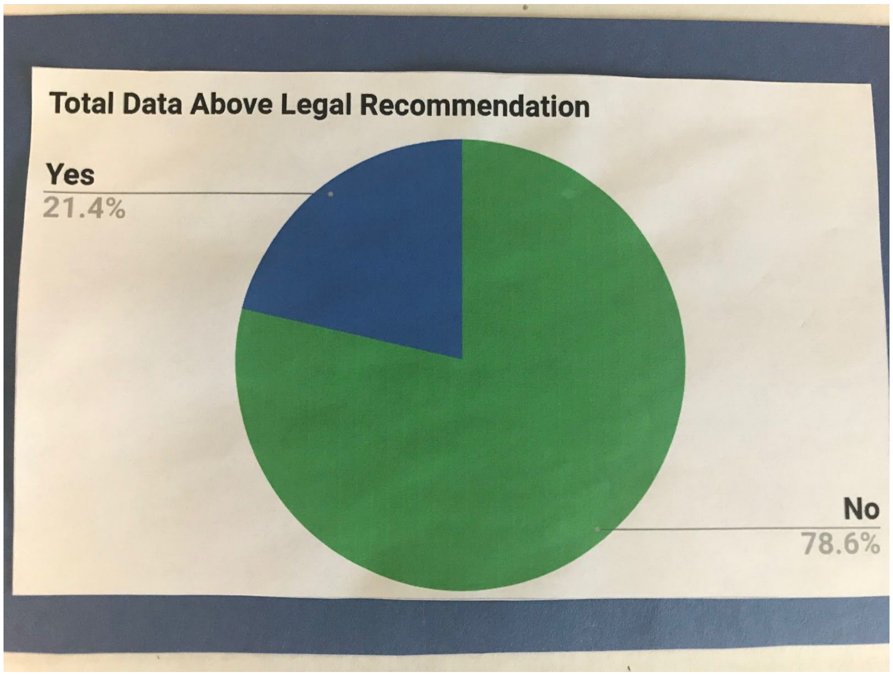
The community meeting was held in conjunction with an annual showcase of student work that is hosted at the Gardiner Regional Middle School. This venue was selected due to the high volume of attendees that it attracts, giving our students a built in audience of a few hundred community members over the course of two hours. As mentioned prior, students were broken into teams and tasked with creating a display that could inform community members of the data we collected and how it relates to the more general risks of arsenic exposure. The competitive nature of this project brought out the best in my students and resulted in the creation of a number of high quality displays. Ultimately, the group that was selected incorporated a mixture of visual displays, images, hands-on examples, and thorough explanations of key concepts.

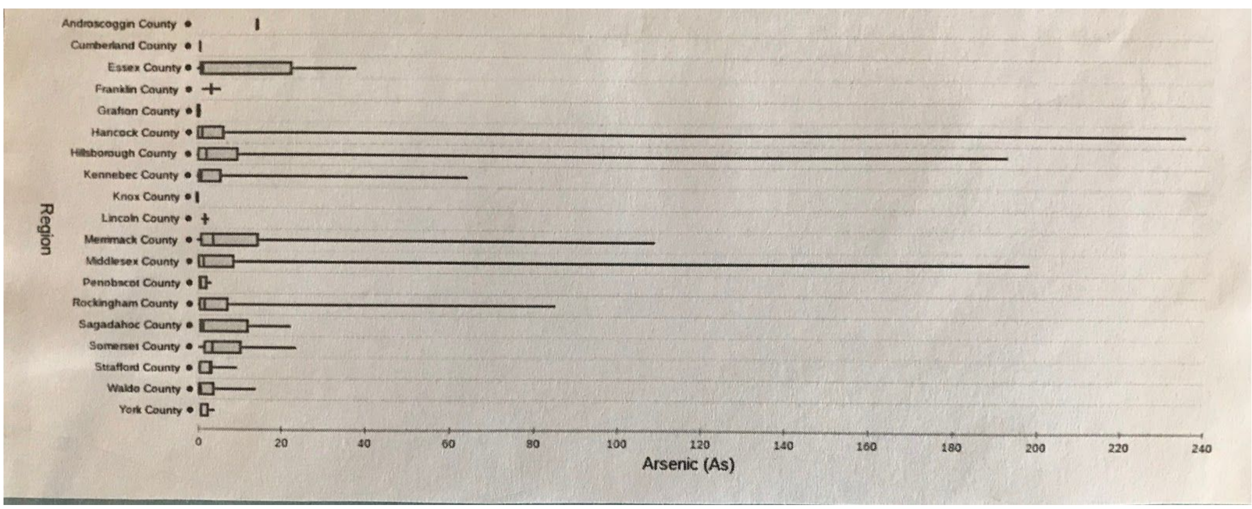
Data Analysis

Below are some example graphs created by my students to represent the data collected during our arsenic study:









Discussion:

The completion of this project led to a number of discoveries for both my students and for myself. This study gave students the opportunity to learn how to operate as citizen scientists and to understand the responsibilities that accompany such a position. It reinforced the idea that science doesn't have to be something reserved for an elite group of highly educated doctors; it can belong to anyone who is willing to apply the correct methods and be honest with their data. It also helped them to develop skills in working as a team, meeting a deadline, and public speaking. All of these are fundamental not only to scientists, but to all members of a functioning society.

As for myself, my lessons were in the challenges associated with the integration of a project of this scope into my curriculum. I underestimated the amount of time it would take to introduce and execute the study which resulted in long nights of planning and a sense of always working from behind. I ended up having to cut out standards I normally covered to make room for the time needed to complete our work. The fault of this lies with me and if I were to repeat the process, I would make several changes to my approach.

1. Take time to plan beforehand. I tried to jump right into the project following the conference with a flimsy plan that needed to regularly be modified as it progressed.
2. Use consequences to keep students motivated. I started this project under the assumption that all my students would be intrinsically motivated to participate in this study. I learned that this was not the case for all students and it led to a disastrous failure in our first attempt. Using grades as leverage ensures that students who lack intrinsic motivators possess an extrinsic one.
3. Keep collecting samples. I was so happy to receive a sample from each student that I never pushed for more. If I were to repeat this process, I would encourage students to push on with their sample collecting. We had very interesting data and I would have loved to see what would have happened had we expanded upon it.

Conclusion:

Participation in this project was a wonderful opportunity for our students and our community. The work the students did will have a genuine impact on Gardiner and its surrounding towns. During our presentation, many citizens expressed concern about their wells and the lack of testing they had performed. Several of our own students discovered high levels of arsenic and uranium and are now filtering their water as a result. Had we not completed this work, many people would be unaware of the toxic effects they are being exposed to daily. These students have had a unique opportunity to work as citizen scientists and my hope is that what they accomplished here will motivate them to continue participating in the scientific community.

References:

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