Subject Area Here

Title of lesson

Subject Area: Chemistry Grade Levels: 9-12th Date Fall 2013

Lesson Overview

Materials Included in this Lesson

- Water data for 2 years on a monthly basis prior to fish kill (this is from the text Chemistry in the Community)
- Water data for the week of the fish kill (this is from the text Chemistry in the Community)
- Stake holder roles
- Town Hall graphic organizer
- Semantic concept map

Other Materials for this Lesson

- Field trip to Nimbus Hatchery
- Lab: pH scale
- Lab: properties of metals in acid
- Lab: pH of rain

Skills the Student will Learn

- graphing data and extrapolation
- concentration units (ppm, molarity)
- solubility and solutions
- pH
- properties of metals
- trends of dissolved solids and gases
- mating patterns for various fish species
- different stakeholders perspectives on habitat vs. business
- the difficult balance between science and society, specifically between ecosystems and human impact

Student Deliverables

1. Teams of students will prepare a graph of data and present to the class their findings
2. Semantic concept map showing ways fish could die, what data they would look at, and what stakeholders would be interested.
3. Teams of students will play the role of various stakeholders in the community and have a prepared Town Hall meeting to discuss:
   - how the fish died
   - who was at fault
   - who will be responsible for clean up
   - who will pay for the clean up and prevention
   - how it will be prevented in the

future.

Length of Lesson: 10-15 Days

- Background info: *You are going to be giving data to students that, when graphed, will lead them to realize that the fish were killed ultimately by heavy metal poisoning. This was possible because the pH in the water dropped because of two reasons: rain is naturally acidic, and heavy rainfall caused agricultural run-off, which further lowered the pH. The heavy metals that are there because of mining during the gold rush and early part of the century were also churned up because of increased water flow because of heavy rains. These heavy rains were seasonally unusual. This churning up of heavy metals wouldn't have been a problem but became one because the acidic nature of the water caused the heavy metals to go into solution which then caused them to kill fish by binding to their organs and causing organ failure. It is also a problem for future fish populations because of the increased cloudiness, turbidity, and decrease pH caused the fish eggs to be destroyed. The increased flow of the river was caused because both Folsom Lake Dam and Nimbus Dam were in danger of flooding thus had to open the dams' wide open. SMUD which uses large hydro benefited from the opening of the dams because they were able to produce quite a bit of energy and met their energy demands which were put on them for the public needed to turn on their heaters.*
  Questions that the kids will need to think about and answer. Was it SMUDs fault for opening the damns? Was it the agricultural group fault for having run-off even though they are careful to only fertilize during the non-rainy season and this was a freak rainstorm? Was it the engineers who designed the dams fault for having a dam that can cause a damaging river flow? Should the dams be retrofitted to make it so they can only be opened at safe flow rates? Is it the mining companies fault who currently follow all guidelines and follow all rules for not dumping heavy metals but whose industry historically caused the metals to be there in the first place? Who will pay for the rehabilitation of the fish species? Who will pay for neutralizing the river? Oh, and let's not forget about the big fishing weekend that had to be canceled because of this. What about the loss of tourist revenue? Do we blame mother nature for raining? Who pays for natural disasters?
  The questions are endless and really get the kids to think about how complicated this situation is and can be.

Activity Day One

- Entry Event: Fish Kill Sacramento (if you can't see this, see below in Student Resources)
- Listen to this recent news story: Cleaning Up the Toxic Legacy of the Gold Rush
- Driving Question: What caused the fish kill in Sacramento, who is at fault and who is responsible for fixing the problems caused?
- Need to Know: brainstorm what student are wondering about at this point, jot this down on the wall of the classroom

Activity Day Two

Diary: water use (see student resources)
Journal Prompt: It takes approximately 120 L of water to produce one 1.2-L can of fruit juice. It takes about 450 L of water to place one fried egg on your breakfast plate. Think of possible explanations for these two facts by listing the steps involved in producing and delivering to your home the fruit juice and the egg. Then review each step and consider where water use would occur.

Activity Day Three

Lab: water purification

Activity Day Four

Graph data and prepare a presentation to the class

Activity Day Five

Presentation to class on the data analyzed

Activity Day Six

- Revisit Diary: Water Use so students can analyze their data and create a class histogram of water use
- Journal:
- Group students into teams of 3-4. Give them stakeholder roles:
    1. SMUD/PG&E
    2. Engineers
    3. Agriculture Representatives
    4. Mining Union
    5. Water Sanitation
    6. Department of Waste
    7. Department of Fish and Wildlife
    8. City of Sacramento Business and Tourism group
    9. City Council/Tax payers

- Revisit need to knows
- Workshop: solubility of solids and gases and reading solubility curves

Activity Day Seven

Guest speaker: Toni Pezzitti, water engineer

Activity Day Eight

Journal: Read/browse this article. Make sure to look at the graphic that goes with this article.

Review your notes from Ms. Pezzetti's presentation.
Now, ask yourself the following:
Why do coastal areas use less water than inland areas?
Why does Folsom use so much water?
Why is water conservation important?
How does what you read about(SacBee) and heard about(Pezzetti) relate to the fish kill project?
What new need to knows do you have?

Cmaptools.com(download this program, it's great): students will map out stakeholders and what they are responsible for concerning the fishkill. *See attached worksheet*

Activity Day Nine

Revisit need to knows
Fieldtrip: Nimbus Hatchery

Activity Day Ten

Prepare graphic organizer (see Student Resources) for Town Hall meeting

Activity Day Eleven

Presentation Town Hall meeting

Activity Day Twelve

Test (reference Student Resources)

Enrichment Suggestions

One suggestion I have for enriching this lesson is what I was fortunate enough to do. If you happen to teacher both chemistry and biology, like me, I had my biology students do an experiment about various water environments and then report their findings during a big lunch presentation to the chemistry students. My biology students created 3 ponds where 1 was normal water (the control), one was acidic (vinegar), and one was organic (plant food). They put various plants and organisms in the three ponds and observed the changes (if any) populations and general health over 3 weeks. They then shared their findings to the chemistry students. I understand that logistically this may not work for many but for me, it was great. I work at a small school and am the only biology and chemistry teacher so this worked for me. I'm sure if your situation is different you might try working with the biology teacher to do something like this. I highly recommend it. I learned about the pond lab from a Sac State Professor, Yana Shober at SIRC(Science in the River City)

Student Resources

There are 4 resources in this section

1. ENTRY EVENT: SACRAMENTO FISHKILL
2. SEMANTIC CONCEPT MAP
3. TEST

4. GRAPHIC ORGANIZER-TOWNHALL MEETING
5. DIARY:WATER USE

ENTRY EVENT: SACRAMENTO FISHKILL

Fish Kill Triggers Sacramento Water Emergency

Severe Water Rationing in Effect

By Lori Katz
Sacramento Bee News Staff Reporter

Citing possible health hazards, Mayor Kevin Johnson announced today that Sacramento will stop withdrawing water from the Sacramento and American River's and will temporarily shut down the water treatment plants including the city's new Freeport Water Intake Facility over water-quality concerns proved by a massive fish kill. Starting at 6 p.m., river water will not be pumped to the plant for at least three days. If the cause of the fish kill has not been determined and corrected by that time, the shut-down will continue indefinitely.

During the plants shutdown, water engineers and chemists from the county

sanitation commission and the U.S. Environmental Protection Agency (EPA) will investigate the cause of the major fish kill discovered yesterday. The fish kill extended from the base of Folsom Dam, located upstream from Sacramento, to the town's water-pumping stations.

The initial alarm was sounded when Marigsa Vergara, 17 and Javier Navarrete, 16 – both students at Sacramento New Technology High School – found many dead fish floating in a favorite fishing spot. "We thought maybe someone had poured poison into the reservoir," explained Vergara.

Senna Davis, the SNTHS biology teacher, accompanied the students back to the river. "We hiked downstream for almost a mile. Dead fish of all kinds were washed up on the banks and caught in the rocks," Navarrete reported.

Ms. Davis contacted county sanitation commission officers, who immediately collected Sacramento and American River water samples for analysis. Chief engineer Hal Cooper reported at last night's emergency meeting that the water samples appeared clear, colorless, and odorless. However, he indicated some concern. "We can't say for certain that the water supply is safe until the cause of the fish kill is determined. It's far better that we take no chances until then," Cooper advised.

Mayor Johnson canceled the community's "Fall Fish-In," which was scheduled to start November 1st. No plans to reschedule Sacramento's annual fishing tournament were announced. "The decision was made at last night's emergency town council meeting to start investigating the situation immediately," he said.

After five hours of often-heated debate yesterday, the Sacramento town council finally reached agreement to stop drawing water from the American and Sacramento Rivers. Council member Ryan Chin (also a chamber of commerce member) commented that the decision was highly emotional and unnecessary. He cited financial losses that motels and restaurants will suffer because the Fish-In cancellation, as well as potential loss for future tourism dollars due to adverse publicity. However, Chin and other council members sharing that view were outvoted by those holding the position that the fish kill, the only one within Sacramento's recorded history, may indicate a public health emergency.

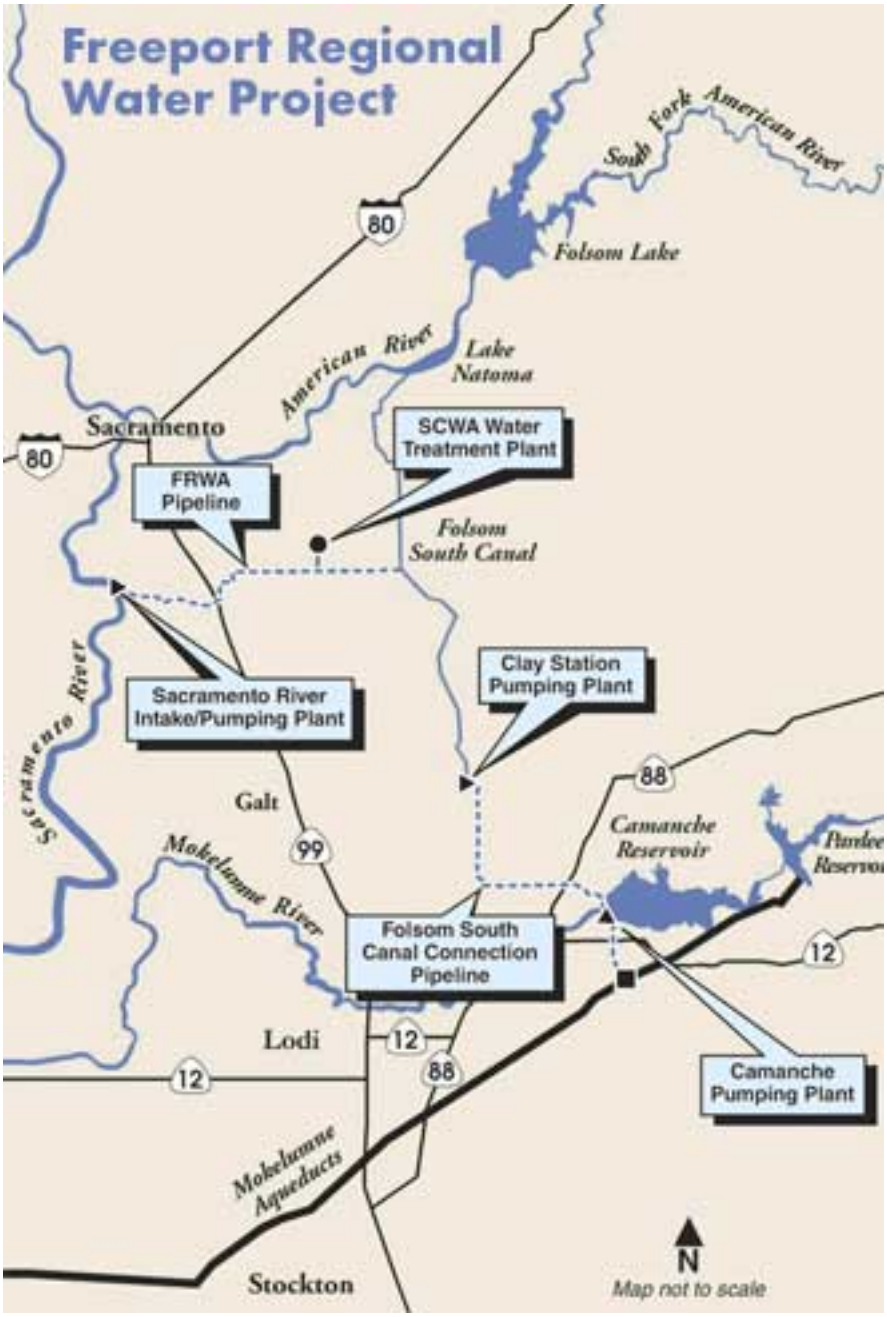
Mayor Johnson assured residents that essential municipal services will not be affected by the crisis. For example, he promised to maintain fire department access to adequate supplies of water to meet firefighting needs.

Arrangements have been made to transport emergency drinking water from Stockton. The first water shipments by truck are due to arrive in Sacramento by midmorning tomorrow. Distribution points are listed in Section 2 of today's *Sacramento Bee*, along with guidelines on conserving water during this emergency.

All Sacramento schools will be closed Monday and possibly through Wednesday. No other closings or cancellations have been announced. Local TV and radio will report any schedule changes as they become available.

A public meeting tonight at 8 p.m. at the town hall features Dr. Margaret Brooke, a water expert at Sac State. She will answer questions concerning water safety and use. Brooke was invited by the county sanitation commission to help clarify the situation for concerned citizens.

Asked how long the water emergency would last, Brooke refused to speculate, saying that she first needed to talk to other scientists conducting the investigation. EPA investigators, in addition to collecting and analyzing water samples, will examine dead fish in an effort to determine what was responsible for the fish kill. Brooke reported that trends or irregularities in water-quality data from American and Sacramento River monitoring during the past two years also will play a part in the investigation.



SEMANTIC CONCEPT MAP

Sacramento Fish Kill Deliverable: Class Concept Map

You will become an expert on possible causes that could've lead to the fish kill. Create a semantic concept map that relates the causes that you researched to who could be responsible and the data you plan on using to support your argument. Color code your semantic concept map to clarify the three categories

How to Kill a Fish? *Color code BLUE*
Molecular Substances

• Heavy rainfall • Detectable levels of pesticides in water or fish • Evidence of pesticide spill
Low Oxygen Level • Heavy rainfall or large release from dam • High water temperatures • Low dissolved oxygen levels • High nitrate and phosphate levels • High organic carbon
Heavy Metal or Mercury Poisoning • Heavy rainfall or large release from dam • High levels of mercury or heavy metals in water • Water having a low pH (acidic)
Gas Bubble Trauma • Large release from dam • High, supersaturated dissolved oxygen levels • Lower water temperatures

Stakeholders *color code RED*	**Data available *color code GREEN***
Mining company	Arsenic (µg/L)
Sacramento county tax payers	Mercury (µg/L)
Power Company (SMUD and PG&E)	PCBs (µg/L)
Construction Company and Engineers	pH
Sacramento County Sanitation	Rainfall (mm)
Agricultural Cooperative	Water temperature (°C)
Chamber of Commerce-tourism	Organic Carbon (µg/L)
	Cadmium (µg/L)
	Lead (µg/L)
	Nitrate (ppm)
	Ortho-phosphate (mg/L)

	Pesticide (mg/L)
	Sacramento and American Rivers waterflow (ft^3 per s)
	Dissolved oxygen (ppm)

TEST:
Graph the data and look for trends and outliers (a.k.a. weird data). The data is on the attached excel spreadsheet

Read about the following air pollutants

- Nitrogen Oxides
- Sulfur Dioxide
- Carbon Monoxide
- Ozone

After graphing the data for Sacramento's air pollution during 2013 and reading about the 4 types of air pollution on the EPA's website, write a 6 paragraph essay analyzing Sacramento's air pollution during 2013. Be sure to copy and paste your graphs into your essay so that you can refer to them in your writing. Questions you might answer in your essay: Are there air pollution problems? Do they happen during a certain time of year or because of some isolated event? Who is at risk because of the levels of pollutants? What can be done about these pollutants? Based on what you know about dissolved gases and solvent temperature make a hypothesis about why you think the trends look the way they do.

1. intro
2. nitrogen oxides
3. sulfur dioxide
4. carbon monoxide
5. ozone
6. conclusion

*See attached excel spreadsheet with raw data

GRAPHIC ORGANIZER-TOWNHALL MEETING
Each team will have a time to speak
Each team will have a time to comment or defend
Each team will have a time to propose their solution

Opening statement: (2minutes/stakeholder group) • *Cause of death of the fish* • *what does the data tell you?* • *whose fault was the fishkill?*
Public comment/defense: (1 minutes/stakeholder group) • *predict why people might blame you and be prepared to defend* OR • *comment on something you heard in the opening statements*
5 minute break to prepare
Prepared Proposed solutions: (2 minutes/stakeholder group)

- *how will the money be spent, who suffered from this disaster and need money?*

- *give the percentage breakdown of who will pay for monetary damages*

- *how will you ensure this doesn't happen in the future?*

Any changes to your proposed solution?

Unit 1
A.2 Making Decisions: Uses of Water

Keep a diary of water use in your home for three days. On this data table, record how often various water-use activities occur. Ask each household member to cooperate and help you.

DATA TABLE			
Per Household	**Day 1**	**Day 2**	**Day 3**
Number of persons			
Number of baths			
Number of showers Average duration of a shower (min)			
Number of toilet flushes			
Number of hand-washed loads of dishes			
Number of machine-washed loads of dishes			
Number of washing-machine loads of laundry			
Number of lawn or garden waterings Average duration of a watering (min)			
Number of car washes			
Number of cups of water (estimated) for cooking and drinking			
Number of times water runs in sink Average duration of water running (min)			

A.7 Making Decisions: Water-Use Analysis

Use the data you collected for Making Decisions A.2 to complete the following analysis of your household's water use. You will then use this information to answer questions about your household's water use and that of your classmates.

Water Usage	Data Table Totals	Conversion Factor	Total Water Used
Number of baths		× 130 L/bath	L
Number of showers × average duration of a shower (min)	min	× 19 L L/min (regular) × 9 L/min (water efficient)	L
Number of toilet flushes		× 19 L/flush (regular) × 13 L/flush (water saving) × 6 L/flush (low-flow)	L
Number of hand-washed loads of dishes		× 114 L/load (with water running) × 19 L/load (washing and rinsing in dishpans)	L
Number of machine-washed loads of dishes		× 61 L/load (full cycle) × 26 L/load (short cycle)	L
Numbers of washing-machine loads of laundry		× 170 L/load	L
Number of lawn or garden waterings × Average duration of a watering (min)	min	× 18.8 L/min	L
Number of car washes		× 680 L/wash	L
Number of cups of water (estimated) for cooking and drinking		× .2 L/cup	L
Number of times water runs in sink × Average duration of water running (min)	min	× 19 L/min (regular) × 26 L/min (water efficient)	L
			L
			L
			L
			L
			L
Total Water Used in Three Days			L

1. Calculate the total water volume (in liters) used by your household during the three days.

_____ L Total Water Volume Used in Household

2. How much water (in liters) did one member of your household use, on average, in one day?

_____ L Average/person/day

3. Compile the answers to Question 2 for all members of your class by creating a histogram. To review the construction of a histogram, see page 13 in your textbook. (*Hint*: The range in values for each histogram bar must be equal and should be selected so that there are about ten total bars.)

4. What is the range of the average daily personal water use within your class?

_____ Class range of average daily personal water use

5. Calculate the mean and median values for the class data. Which do you think is more representative of the data set—the mean or median value? That is, which is a better expression of central tendency for these data?

Class mean _____ Class median _____

6. Compare your answer to Question 2 with the estimated average volume of water, which is 370 L, used daily by each person in the United States. What reasons can you propose to explain any difference between your value and the national average value?

7. Which is closer to the national average (mean) for daily water use by each person, your answer to Question 2 or the class average in Question 4? What reasons can you give to explain why that value is closer?

8. On the basis of the water-use data collected and analyzed by your class (pages 8–9 and 19–20 of your textbook) explain how you would estimate the total volume of water that would need to be hauled to Riverwood during the three days.

9. What additional information would help you improve your estimate in Question 8? Why?

10. What assumptions must you make to complete your estimate?

Next Generation Science Standards

HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. [Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.] [*Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure*.]

HS-PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. [Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.] [*Assessment Boundary: Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature*.

HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.]

HS-ESS3-3. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. [Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning.] [*Assessment Boundary: Assessment for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations*.]

HS-ESS3-5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems. [Clarification Statement: Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition).] [*Assessment Boundary: Assessment is limited to one example of a climate change and its associated impacts*.]

Common Core-Math

MP.4 Model with mathematics. *(HS-PS1-8)*

HSN- Use units as a way to understand problems and to guide the solution of multi-step

Q.A.1 problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. *(HS-PS1-3)*,(HS-PS1-8),*(HS-PS2-6)*

HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS1-8),*(HS-PS2-6)*

HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. *(HS-PS1-3),(HS-PS1-8),(HS-PS2-6)*

Common Core-ELA

WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. *(HS-PS1-3)*

RST.9-10.7 Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words. *(HS-PS1-1)*

CTE Pathway Standards

AGRICULTURE AND NATURAL RESOURCES INDUSTRY SECTOR
D. Animal Science Pathway
D7.0 Students understand common rangeland management practices and their impact on a balanced ecosystem:
D4.0 Students understand animal reproduction, including the function of reproductive organs:
D9.0 Students understand animal welfare concerns and management practices that support animal welfare:
E. Forestry and Natural Resources Pathway
E5.0 Students understand wildlife management and habitat:
E6.0 Students understand aquatic resource use and management:
G. Plant and Soil Science Pathway
G8.0 Students understand effective water management practices:

Lesson Plan Relevance To Externship

My lesson plan is relevant to my externship because of two reasons. Fish kills happen in the Sacramento area for multiple reasons and most are caused by human impact. Having students become aware of this is very powerful for them to realize their place in their ecological community. Secondly, I learned about all of the resources that Nimbus Hatchery has to offer. It is always powerful to get students out of the classroom and into the actual resource to help them better come up with solutions to problems.

NTN Knowledge and Thinking Rubric for Scientific Research, Grade 12

The ability to reason, problem-solve, develop sound arguments or decisions, and create new ideas by using appropriate sources and applying the knowledge and skills of a discipline

REPRESENTING ANALYZING, AND INTERPRETING THE DATA

What is the evidence that the student can organize, analyze, and interpret the data?

	EMERGING	E/D	DEVELOPING	D/P	PROFICIENT College Ready	P/A	ADVANCED College Level
USING MATHEMATICS AND COMPUTATIONAL THINKING (WHEN APPROPRIATE)	• Expresses relationships and quantities (units) using mathematical conventions with major errors • Evaluation of whether the mathematical computation results "make sense" is omitted		• Expresses relationships and quantities (units) using mathematical conventions with minor errors • Makes note of whether the mathematical computation results "makes sense" without reference to the expected outcome		• Accurately expresses relationships and quantities (units) using appropriate mathematical conventions • Explains whether the mathematical/computation results "make sense" in relationship to the expected outcome		• Accurately and consistently expresses relationships and quantities (units) using appropriate mathematical conventions • Consistently evaluates whether the mathematical/computation results "make sense" in relationship to the expected outcome
USING MATHEMATICS AND COMPUTATIONAL THINKING (WHEN APPROPRIATE)	• Expresses relationships and quantities (units) using mathematical conventions with major errors • Evaluation of whether the mathematical computation results "make sense" is omitted		• Expresses relationships and quantities (units) using mathematical conventions with minor errors • Makes note of whether the mathematical computation results "makes sense" without reference to the expected outcome		• Accurately expresses relationships and quantities (units) using appropriate mathematical conventions • Explains whether the mathematical/computation results "make sense" in relationship to the expected outcome		• Accurately and consistently expresses relationships and quantities (units) using appropriate mathematical conventions • Consistently evaluates whether the mathematical/computation results "make sense" in relationship to the expected outcome
ANALYZING THE DATA	• Analyzes data using inappropriate methods or with major errors or omissions • Consistency of outcome with initial hypothesis, when appropriate, is not compared		• Accurately analyzes data using appropriate methods with minor omissions • Compares consistency of outcome with initial hypothesis, when appropriate		• Accurately analyzes data in using appropriate and systematic methods to identify patterns • Compares consistency of outcome with initial hypothesis when appropriate and identifies possible sources of error		• Accurately analyzes data in using appropriate and systematic methods to identify and explain patterns • Compares and explains consistency of outcome with initial hypothesis, when appropriate and explains possible sources of error and impact of errors

	investigation		need further investigation		• Suggests relationships or interactions between variables worth further investigation		• Suggests relationships or interactions between variables worth further investigation and poses new analysis or study

CONSTRUCTING EVIDENCE-BASED ARGUMENTS AND COMMUNICATING CONCLUSIONS

What is the evidence that the student can articulate evidence-based explanations and effectively communicate conclusions?

	EMERGING	E/D	DEVELOPING	D/P	PROFICIENT College Ready	P/A	ADVANCED College Level
CONSTRUCTING EVIDENCE-BASED ARGUMENTS	• Argument is missing or unclear; supporting data or scientific theory are missing • Counterclaim (possible weaknesses in scientific arguments or in their own argument) is missing		• Constructs a scientific argument and mentions data OR acceptable scientific content or theory but does not explain how it supports the claim • Identifies a counterclaim (possible weaknesses in scientific arguments or in one's own argument) without mentioning evidence		• Constructs a scientific argument, explaining how data and acceptable scientific content or theory support the claim • Identifies a counterclaim (possible weaknesses in scientific arguments or in one's own argument) using evidence		• Constructs and evaluates a scientific argument explaining how data and acceptable scientific content or theory support the claim • Explains and evaluates a counterclaim (possible strengths and weaknesses in scientific arguments or in one's own argument) using evidence
COMMUNICATING FINDINGS	• Attempts to use multiple representations to communicate conclusions with inaccuracies or major inconsistencies with the evidence • Implies conclusions with no discussion of limitations		• Uses multiple representations (words, tables, diagrams, graphs and/or mathematical expression) to communicate conclusions with minor inconsistencies with the evidence • States conclusions and general discussion of limitations		• Uses multiple representations (words, tables, diagrams, graphs, and/or mathematical expressions) to communicate clear conclusions consistent with the evidence • Explains conclusions with specific discussion of limitations		• Uses multiple representations (words, tables, diagrams, graphs, and/or mathematical expressions) to communicate clear and specific conclusions consistent with the evidence • Explains conclusions and impact of limitations or unanswered questions
FOLLOWING CONVENTIONS	• Uses language and tone inappropriate to the purpose and audience • Attempts to follow the norms and conventions of scientific writing with major, consistent errors, for example in the use of scientific/technical terms, quantitative data, or visual representations		• Uses language and tone appropriate to the purpose and audience with minor lapses • Follows the norms and conventions of scientific writing with consistent minor errors, for example in the use of scientific or technical terms, quantitative data, or visual		• Uses language and tone appropriate to the purpose and audience • Follows the norms and conventions of scientific writing, including accurate use of scientific/technical terms, quantitative data, and visual representations		• Uses language and tone appropriate to the purpose and audience • Consistently follows the norms and conventions of scientific writing, including accurate use of scientific/technical terms, quantitative data, and visual representations

			representations				

NTN Knowledge and Thinking Rubric for Science Argumentation, Grade 12

The ability to reason, problem-solve, develop sound arguments or decisions, and create new ideas by using appropriate sources and applying the knowledge and skills of a discipline.

	EMERGING	E/D	DEVELOPING	D/P	PROFICIENT College Ready	P/A	ADVANCED College Level
ARTICULATING A SCIENCE-RELATED ISSUE *What is the evidence that the student can articulate a clear issue and explain its scientific context?*	• The scientific, social or technological significance of the issue is missing, vague, or unclear • Scientific content is limited and/or contains inaccuracies • Does not situate the issue within any other context		• The scientific, social or technological significance of the issue is clear, but lends itself to readily available answers • Scientific content is limited but accurate • Makes references to another context		• The scientific, social, or technological, significance of the issue is thoughtful and lends itself to a challenging research project • Scientific content is clear, detailed and relevant • Situates issue in a cultural, historical, and/or global context		• The scientific, technological or social significance of the issue is thought-provoking and lends itself to a challenging and interesting research project • Scientific content is clear, detailed, accurate, and relevant, and conveys depth and breadth of knowledge on the topic • Situates the issue within their genres: cultural, historical, global context and elaborates on the significance of the issue in these contexts
ARGUMENT *What is the evidence that the student can develop an argument?*	• Argument is unclear or underdeveloped • Makes unclear or irrelevant claims • One claim dominates the argument and alternative or counterclaims are absent		• Makes a somewhat clear, but general argument • Makes relevant claims • Briefly alludes to questions or counterclaims		• Makes a clear and well developed argument • Makes relevant claims that support the argument • Acknowledges questions or counterclaims		• Makes a clear, well developed, precise, and nuanced argument • Makes relevant and significant claims that support the argument • Acknowledges and responds to questions or counterclaims to sharpen the argument

EVIDENCE *What is the evidence that the student can support the argument?*	• Refers to evidence from few sources; some sources may not be relevant • Limited use of data and/or examples • Makes note of a general difference in perspectives on a topic without specific details		• Refers to limited evidence (textual, experimental, or multimedia) relevant to argument • Data and/or examples are used to illustrate one point of view • Briefly notes and dismisses inconsistent information or a difference among authors on the same topic		• Refers to sufficient and detailed evidence (textual, experimental, or multi-media) relevant to argument • Data and/or examples are used to illustrate varying points of view • Discusses inconsistent information and differences among authors on the same topic	• Refers to extensive and comprehensive evidence (textual, experimental, or multimedia) relevant to argument • Data and/or examples are used to illustrate different points of view and justify the claim • Weighs and evaluates inconsistent information and differences among authors on the same topic
ANALYSIS *What is the evidence that the student can analyze evidence?*	• Restates information from multiple sources • Expresses broad agreement with a source's perspective without assessing the strength or limitation of the source		• Summarizes evidence from multiple sources related to the argument • Minimally addresses the strength or limitation of one important source		• Synthesizes evidence from multiple sources related to the argument • Assesses the strengths or limitations of most important sources to support the argument or claims	• Synthesizes and critiques evidence from multiple sources related to the argument • Assesses the strengths and limitations of most important sources to support or refute the argument or claim
CONCLUSION *What is the evidence that the student can draw logical and sound conclusions?*	• Conclusions are stated vaguely or generally, or are implausible • Conclusions are overstated or overdrawn		• Conclusions are logical, and generally plausible; no further implications are raised • Briefly notes limitations or unanswered questions		• Conclusions are logical and well supported; raises plausible implications • Discusses limitations and/or unanswered questions	• Conclusions are logical, well supported, and insightful, and raise important implications • Discusses limitations, unanswered questions, and/or considers alternative explanations

NTN Oral Communication, High School

The ability to communicate knowledge and thinking through effective oral presentations.

	EMERGING	E/D	DEVELOPING	D/P	PROFICIENT College Ready	P/A	ADVANCED College Level
CLARITY *What is the evidence that the student can present a clear perspective and line of reasoning?*	• Presents an unclear perspective • Line of reasoning is absent, unclear, or difficult to follow		• Presents a general perspective • Line of reasoning can be followed		• Presents a clear perspective • Line of reasoning is clear and easy to follow • Addresses alternative or opposing perspectives when appropriate		• Presents a clear and original perspective • Line of reasoning is clear and convincing • Addresses alternative or opposing perspectives in a way that sharpens one's own perspective

NTN Agency Rubric, High School

Take Ownership Over One's Learning: *I can learn how to learn and monitor progress to be successful on tasks, school, and life.*

	EMERGING	E/D	DEVELOPING	D/P	PROFICIENT College Ready	P/A	ADVANCED College Level
Impact Self & Community	• Identifies the ups and downs of the classroom and home community		• Has limited understanding of individual role in the ups and downs of the classroom and home community		• Analyzes individual role in the ups and downs of the classroom and home community		• Monitors and adjusts individual role to positively influence the ups and downs of the classroom and home community
Actively Participate	• Stays focused for part of the activity/discussion, team meeting, or independent time but often cannot resist distraction or does not notice when or why a loss of focus		• Mostly stays focused on the activity/discussion, team meeting, or independent time and knows when and why disengagement or distraction happens		• Actively participates in the activity/discussion, team meeting, or independent time and has strategies for staying focused and resisting most distraction		• Actively participates and takes initiative on the activity/discussion, team meeting, or independent time and has personal strategies for staying focused
Seek Feedback	• Rejects feedback and/or does not revise work		• Sometimes shows evidence of accepting feedback to revise work, but at times may resist when it's difficult		• Consistently shows evidence of accepting and using feedback to revise work to high quality		• Consistently shows evidence of actively seeking, identifying, and using feedback to revise work to high quality
Meet Benchmarks	• Completes few benchmarks and class assignments and may resist or struggle to use resources and supports (i.e. study groups, teacher support, workshops, tutorials)		• Completes some benchmarks and class assignments; and, only when forced to, or at the last minute, uses resources and supports (i.e. study groups, teacher support, workshops, tutorials)		• Usually completes polished benchmarks and class assignments by using resources and supports when necessary (i.e. study groups, teacher support, workshops, tutorials)		• Achieves personal best work on almost all benchmarks and class assignments by setting goals, monitoring progress, and using resources and supports (i.e. study groups, teacher support, workshops, tutorials)

Develop Growth Mindset: *I can grow my intelligence and skills through effort, practice, and challenge. The brain grows bigger with use, like a muscle.*

	EMERGING	E/D	DEVELOPING	D/P	PROFICIENT College Ready	P/A	ADVANCED College Level
Build Confidence	• Struggles to identify academic strengths, previous successes, or endurance gained from personal struggle to build confidence in academic success for a new task, project, or class		• Identifies an academic strength, previous success, or endurance gained through personal struggle, but does not use these skills to build confidence in success for a new task, project, or class		• Builds confidence in success (on a new task, project, or class) by knowing and using academic strengths, previous success, or endurance gained through personal struggle		• Consistently confident that success is possible (on a new task, project, or class) by knowing and using academic strengths, previous successes, or endurance gained through personal struggle
Find Personal Relevance	• Rarely, and with significant support, finds personal relevance in the work by connecting it to interests or goals, reflecting on progress towards mastery, or identifying autonomous choices		• With support, sometimes finds personal relevance in the work by connecting it to interests or goals, reflecting on progress towards mastery, or identifying autonomous choices		• Often finds personal relevance in the work by connecting it to interests or goals, reflecting on progress towards mastery, or identifying autonomous choices		• Independently seeks and finds personal relevance in the work by connecting it to interests or goals, reflecting on progress towards mastery, or identifying autonomous choices
Seek Challenge	• Rarely takes on academic challenge and risks to pursue learning • Struggles to identify the personal barriers (mindset, beliefs, circumstances) that inhibit taking risks		• With encouragement, sometimes takes on academic challenge and risks to pursue learning • Superficially describes personal barriers (mindset, beliefs, circumstances) that inhibit taking risks		• Seeks academic challenge and takes risks to pursue learning • Analyzes personal barriers (mindset, beliefs, circumstances) that inhibit taking risks		• Strategically and independently seeks academic challenge and takes risks to pursue learning • Analyzes and overcomes personal barriers (mindset, beliefs, circumstances) that could inhibit taking risks