Noticing and Wondering, Who Decides How a River is Made?

Vicki Baker

Content Objectives

In my seminar, Environmental Humanities from the Tidal Schuylkill River, we explored the lower, tidal, Schuylkill River as a lens through which to consider both local and global issues: the right to the city and the rights of nature, citizenship, uneven neighborhood development, and global warming, including sea level rise. I have utilized seminar material about the Schuylkill to create high school math lessons emanating from our discussions on the effect that global warming and climate change are predicted to have on the land surrounding the Schuylkill River and the City of Philadelphia and what we, its residents, can do to "just transition" and create resilient futures. This curriculum unit educates students about the effects of global warming and the causes of climate change by using the background information learned in the seminar as the "storyline" for Algebra 2 mathematical content. Students also learn about the personal, individual changes as well as the larger societal changes that will help us change course.

This curriculum unit covers climate change and the effects that average temperature increases will have both on the Schuylkill River as well as nearby Philadelphia neighborhoods. Student inquiry methods include "noticing and wondering" as well as "productive struggle." These methods strengthen students' critical thinking skills, increasing their ability to "make sense of problems" and to "persevere in solving them." I wish to deepen my students' math acumen by incorporating real life, relevant, authentic lessons into the curriculum.

Problem Statement

I teach high school math at The Philadelphia High School for Girls, a school with a rich history of academic excellence. Founded in 1848 to "prepare teachers for the common schools of Philadelphia," Girls' High, as it is affectionately known, was the first municipally supported secondary school for girls in the United States and was called the Girls' Normal School. In 1893, the Philadelphia High School for Girls separated from the Girls' Normal School, and the foundation for today's college preparatory curriculum was laid. The school continues its legacy as a school for academically talented girls, providing young women with outstanding opportunities for scholarship, leadership, and service. Its motto, "Vincit qui se vincit" (He conquers who conquers himself), is a key centering point for our students maturing into young woman of purpose and honor (Cutler, 2013).

When I think about my students at the Philadelphia High School for Girls, I think about a group of highly able learners who bring energy and the thirst for learning when they interact with each other and question both the content and relevance of the work they are given. My students are as diverse as the City of Philadelphia having applied and gained admission from diverse neighborhoods and middle schools of every type (public, private, parochial, magnet and neighborhood) from all over the city. By the time they enroll in high school they have taken high school preparatory courses in almost every subject.

Nonetheless, across all grades, their math skills are often rudimentary and reflect rote learning. Their math knowledge consists of algorithms and formulas of which they have little practical knowledge, and they do not see how those skills apply to real world applications. While my students have solid math skills and a strong grasp of math fundamentals, they lack the ability to apply these skills to new math content and to solve word problems. My students read the problem and focus narrowly on the question. They focus on remembering "the right way," the "formula" or "algorithm," or "the prior lesson" required to solve it. They are not able to "notice" the details of the problem or then use what they notice to trigger their prior math knowledge, the math already in their head, to then connect the math in the problem to the mathematical ideas they could use to move toward a solution.

Math knowledge is key to student achievement in Science, Technology Engineering and Mathematics. The critical thinking skills and ability to see patterns and analyze materials in other classes make math one of the most important disciplines in a students' education. (Schornick, 2010) The National Academy of Sciences (1989) discussed the importance of a strong mathematics background when they stated:

> "Mathematics reveals hidden patterns that help us understand the world around us. Now much more than arithmetic and geometry, mathematics today is a diverse discipline that deals with data, measurements, and observations from science; with inference, deduction, and proof; and with mathematical models of natural phenomena, of human behavior, and of social systems. (p. 31) Current high school graduates must hold skills in critical thinking, problem solving, and analysis in order to succeed in the most modest of ways." Further, Wimberly and Noeth noted: "The shift from an industrial economy to one based on service, information, and technology has dramatically increased the importance of advanced skills and credentials" (Wimberly & Noeth, 2005, ~~p. 1~~).

Now, thirty years after the National Academy of Sciences' statements, and a dozen after Wimberly & Noeth's paper, the skills a student needs to be successful require more finely hones skills, '21st Century Skills" have been defined outlining skills needed to compete in the global economy of today.

In 1989, the same year, as the National Academy of Science report was issued, the National Council of Teachers of Mathematics (NCTM) released the Curriculum and

Evaluation Standards for School Mathematics, "an initiative to promote systemic improvement in mathematics education," It launched the standards-based education movement in North America. Now, twenty-five years later, college- and career-readiness standards, including adoption of the Common Core State Standards for Mathematics (CCSSM), provide an opportunity to reenergize and focus our commitment to significant improvement in mathematics education. What is different and promising today, however, is the hope that the implementation of common standards, and the new generation of aligned and rigorous assessments, will help to address the continuing challenges and expand the progress already made. The need for coherent standards that promote college and career readiness has been endorsed across all states and provinces, whether they have adopted CCSSM. As NCTM publicly declared in the Position Statement Supporting the Common Core State Standards for Mathematics, released in 2013.The widespread adoption of the Common Core State Standards for Mathematics presents an unprecedented opportunity for systemic improvement in mathematics education in the United States. The Common Core State Standards offer a foundation for the development of more rigorous, focused, and coherent mathematics curricula, instruction, and assessments that promote conceptual understanding and reasoning as well as skill fluency. - is foundation will help to ensure that all students are ready for college and the workplace when they graduate from high school and that they are prepared to take their place as productive, full participants in society. (NCTM, 2013).

Today, student achievement is at historic highs. For example, the percentage of fourth graders scoring "proficient" or above on the National Assessment of Educational Progress (NAEP) rose from 13 percent in 1990 to 42 percent in 2013, and the percentage of eighth graders scoring "proficient" or above on the NAEP rose from 15 percent in 1990 to 36 percent in 2013. Between 1990 and 2013, mean SAT-Math scores increased from 501 in 1990 to 514 in 2013, mean ACT scores increased from 19.9 to 20.9, and the number of students taking Advanced Placement examinations in calculus and statistics increased substantially, from 77,634 in 1982 to 387,297 in 2013, and from 7,667 in 1997 to 169,508 in 2013, respectively. - ese are impressive accomplishments. However, while we celebrate these record high NAEP scores and increases in SAT and ACT achievement—despite a significantly larger and more diverse range of test-takers—other recent data demonstrate that we are far from where we need to be and that much remains to be accomplished. For example, the average mathematics NAEP scores for 17-year-olds has been essentially at since 1973; the difference in average NAEP mathematics scores between white and black and white and Hispanic 9- and 13-year-olds has narrowed somewhat between 1973 and 2012 but remains between 17 and 28 points; and among cohorts of 15-year-olds from the 34 countries participating in the 2012 Program for International Student Assessment (PISA), the U.S. cohort ranked 26th in mathematics.

~~Insert Mathematical teaching practices here (list with short explanation – long in appendix)~~

While the NCTM Principles to Action reports positive trends in education, it also indicates that there are still large disparities among racial and ethnic minority groups. The report says: "...too few students – especially those from traditionally underrepresented groups – are attaining high levels of mathematics learning. Test data comparisons from the PA Keystone Algebra 1 test for magnet schools in Philadelphia also show disparities in performance measured across underrepresented racial minorities.

Category	**School A**	**School B**	**School C**
Keystone Algebra 1 (Proficient & Advanced)	98.6%	72.7%	78.6%
Black	21	66	44
Asian	39	16	28
Latina	7	9	11
Multi/Other	7	5	5
White	28	3	12

Girls' High School test results resemble the above data with demographics of75% racial minorities and overall Keystone Algebra 1 scores in the 70's. Strategies to improve math achievement are important for increased performance. In order to achieve the academic results student, the depth of mathematical learning and ability to solve complex problems must be addressed.

Background Information

Our seminar's journey began, as the syllabus describes, with a "survey of how the Schuylkill River has been represented over time, in maps and other visual and textual artifacts" The early readings guided our discussions on the " ways we 'know' the Schuylkill, and other rivers." We discussed how our own experiences "informed how we understand this waterscape," and we "considered how this location shapes our conceptions of the global processes, systems, and challenges which shape and re-shaped the course of the river since the beginning of European settler colonialism in North America." Over the course of the seminar we considered various questions: "How do we know and understand this place where industrial zones intersect with recreational paths, where hardened embankments are increasingly waterlogged? What kinds of information do we, who work and perhaps live in the Schuylkill watershed, have available to us? What kinds of information might we wish to have? How are legacies from the

Schuylkill's past flowing into the future?" Our discussions "deepened our understanding of the tidal river" and introduced global warming and other processes related to climate change as issues close to home and as happening in the present.

Our discussions have shaped my curriculum unit. For me, a powerful, overarching question is: "Who decides?" As our seminar's readings indicate, there are many answers to this question: mother nature decides, developers decide, citizens and residents decide, and the rising of rivers due to climate change, may ultimately decide. The river and its rights have been taken over by many convinced they have the power and the authority to determine its future. So, who decides?

Nature Decides

In the first weeks of the course, we read articles and excerpts concerning the Schuylkill river and its course, where it flows, and activity on the shores and in the water.

In Dilip da Cunha's *The Invention of Rivers: Alexander's Eye and Ganga's Descent* we discussed the significance of the placement of a line on a map representing a river. The line, decided by others, often outsiders (like colonial Europeans) effected the entire region because it locked flowing water to a place and to a time. Water was designated to keep this place even over the course of great seasonal variation, inclusing the monsoon. The infrastructure of this region—and for building rivers across the globe--further locked the water in place with a regimes of levees, spillways, jetties, revetments and cutoffs (Cunha (XX). But the Ganga and its water "refuse" to be restricted, so nature decides where it flows.

The flow of the river was also the topic of Beth Kephart's *Flow*, a narrative featuring two voices: one, that is a lyrical attempt to give the river itself a voice and a second, which offers third-person analytic observations of the river over time. *Flow* personalizes many aspects of the river: animals, people out and about, and even location itself, where the river starts as a trickle. Characters "decide" what the river is based on the story told on their behalf.

Our seminar eventually defined the river as a live body that flows where it wants and when it wants under the assumed control of others (man) but beholden to itself and the wildlife who depend on it. For humans who live with the land and river as one, they are all one community.

The Schuylkill River is also made up of waters that didn't originate as a trickle in the mountains. The Schuylkill watershed gathers water from many other sources. We learned about a network of creeks and streams that are underground and controlled by large sewer systems. Especially with more severe rain events now occurring more frequently—another local effect of ongoing climate change--the historic creeks will likely play a large part in flooding. Rising waters in Philadelphia may occur from our grey infrastructure's inability to absorb water, as the flow overpowers the hard system created to contain it. Here the water or mother nature herself can be heard speaking as the characters' words echo the river and nature decides.

The Powerful Decide

Forgotten places and those other select to be forgotten – who decides?
June 21 EPA relaxes fossil fuel emission standards (Coal)

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Environment Forces Decide

How Can We Understand Climate Change from/with the tidal Schuylkill?
Climate change in general (attitudes the dynamics of who believes and who doesn't believe; Evidence from the websites which model climate change

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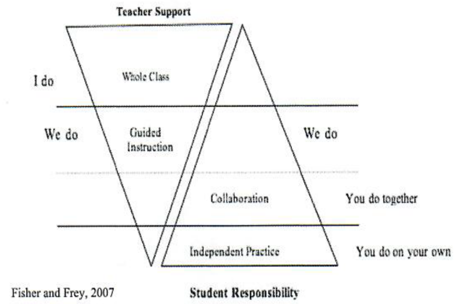
Teaching Strategies

Teaching strategies are implemented to meet the lesson objectives by imparting knowledge of a new concept through the instruction. PA math standards for all subjects state that students will be taught. to "interpret solutions to problems in the context of the problem situation" or "interpret (subject matter) in terms of the situation they model." These tasks require a deeper mathematical understanding of the subject matter. Traditional lessons for generations have utilized models where the teacher delivered the instruction to students who listened and took notes. Teaching strategies have evolved recently to what educational leaders describe as a less teacher-centered approach and more student-centered approach. In the early 21st century, scaffolded instruction was adopted as a preferred method in an industry attempt to improve student performance and convert classroom instruction from whole-group and teacher-centered to student-centered. Recently, evaluation of learning in math classrooms has given rise to anther model, productive struggle, which aims to increase students' critical thinking skills while increasing their ability to independently link their own math content to new problems without initial teacher input. The lessons in this curriculum unit are modeled after the "productive struggle" pedagogical educational model rather than solely the scaffolded instruction or the gradual release model of instruction. Each model is discussed below.

Gradual Release of Responsibility Model

Gradual release of responsibility model or scaffolded instruction model of instruction is considered a successful teaching strategy. It was defined to convert classroom instruction from whole-group and teacher-centered to student-centered.

This model provides a structure for teachers to move from assuming "all the responsibility for performing a task" to a situation in which the students assume all of the responsibility" (Duke & Pearson, 2004, p. 211). The model is built on several theories:



- Jean Piaget's work on cognitive structures and schema (1952).
- Lev Vygotsky's work on zones of proximal development (1962, 1978).
- Albert Bandura's work on attention, retention, reproduction, and motivation (1965).
- David Wood, Jerome Bruner, and Gail Ross's work on scaffolded instruction (1976).

(Fischer and Frey, 2007)

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This model outlines an instructional plan which starts with whole-class instruction by the teacher and slowly "releases" the instruction to student control. The gradual release method is often called the I do, we do, you do instructional plan as the teacher begins by teaching the lesson (I do), when appropriate, models problems jointly with students (we do) and then as the students become more proficient assigns problems for the students to work on independently (you do).

Mentoring Roles & Responsibilities

	Teacher	Student
I do it *Direct Instruction*	▪ Provides direct instruction ▪ Establishes goals and purpose ▪ Models ▪ Think aloud	▪ Actively listens ▪ Takes notes ▪ Asks for clarification
We do it *Guided Instruction*	▪ Interactive instruction ▪ Works with students ▪ Checks, prompts, clues ▪ Provides additional modeling ▪ Meets with needs-based groups	▪ Asks and responds to questions ▪ Works with teacher and classmates ▪ Completes process alongside others
You do it independently *Independent Practice*	▪ Provides feedback ▪ Evaluates ▪ Determines level of understanding	▪ Works alone ▪ Relies on notes, activities, classroom learning to complete assignment ▪ Takes full responsibility for outcome
You do it together *Collaborative Learning*	▪ Moves among groups ▪ Clarifies confusion ▪ Provides support	▪ Works with classmates, shares outcome ▪ Collaborates on authentic task ▪ Consolidates learning ▪ Completes process in small group ▪ Looks to peers for clarification

Developed by Ellen Levy © E.L.Achieve/2007

The gradual release method is less teacher-centered because even though the lesson begins with the teacher as the sole deliverer of instruction, the students participate fully in the last two parts of the model; relying completely on their own understanding in the last step to complete the problems. The roles and responsibilities of the gradual release method are outlined in the chart below (Ellen Levy, Achieve/ 2007)

Productive Struggle

“Productive struggle is the process of effortful earning that develops grit and creative problem solving” - Mind Research Institute

The Common Core math standards requires students to develop and demonstrate more conceptual understanding of mathematical concepts. The transferable skills resulting from developing this skill are increased critical thinking skills and more highly developed problem-solving skills. Research shows that math is enjoyed and remembered when students are engaged in the lesson and when the lesson includes a teacher driven, planned struggle called in math pedagogy “productive struggle”. (NCTM, Principles to Action)

Many students complete high school without having developed conceptual skills which are flexible enough to allow them to draw connections and transfer skills to more difficult problems (Lindsey 2012). Recent National Council of Teachers of Mathematics (NCTM, 2014) recommend that teachers “supply more opportunities for students to engage in productive struggle by solving word problems and challenging mathematical tasks. The instructional model consistent with these objectives is the productive struggle model. This model “flips over” the gradual release model in the sense that it is implemented in the reverse order.

The productive struggle model is a complete process; different from a single problem of the day or challenge problem after a lesson. It allows students to apply their knowledge without relying in a teacher as the authority and answer giver.

Model: Gradual Release

1. I Do
2. We Do
3. You Do

Model: Productive Struggle

1. You Do
2. We Do
3. I Do

Research shows that math lessons utilizing the productive struggle model, which are rich, meaningful and authentic increase student engagement and result in greater learning. In the May, 12, 2019 New York Times article “Math, Taught Like Football”, John Urschel, current Pd.D. candidate in mathematics at the Massachusetts Institute of Technology, and a former Penn State and Baltimore Ravens NFL football offensive lineman, discusses his early relationship with math, the features that bored, excited and finally motivated him. Urschel's earliest memories are those of boredom. He says: "Growing up, I thought math class was something to be endured, not enjoyed. I disliked memorizing formulas and taking tests, all for the dull goal of getting a good grade. In elementary school, my mind wandered so much during class that I sometimes didn't respond when I was called on, and I resisted using the rote techniques we were taught to use to solve problems. One of my teachers told my mother that I was "slow" and should repeat a grade." He remembers being excited about math when it was presented as a challenge: "I spent countless hours as a child doing logic and math puzzles on my own, and as a teenager, when a topic seemed particularly interesting, I would go to the library and read more about it." And in college a professor sought HIM out to: "summoned me to his office, handed me a book and suggested that I think about a particular problem. Understanding it, I realized, required reading other, more elementary books. I would make my way down one path only to hit a dead end. It wasn't easy, but it was fascinating". Finally, his math experience motivated him to excel. He writes "My professor kept giving me problems, and I kept pursuing them, even though I couldn't always solve them immediately. Before long, he was introducing me to problems that had never been solved before and urging me to find new techniques to help crack them."

Urschell describes the final experience as harkening back to his early math experiences "it was closer to the math and logic puzzles I did on my own as a boy. It gave me that same sense of wonder and curiosity, and it rewarded creativity." Until the college experience provided by his professor, the true essence of math was "I had no desire to spend my life doing exercises out of a textbook, which is what I assumed mathematicians did" he saw math as "problem sets and laborious computations." And now "I still feel that childlike excitement every time I complete a proof. I wish I'd known this was possible when I was a kid." To transfer this type of excitement and zeal for math to our students - what tremendous joy it gives teachers just to think about it!

This joy is the essence of math discovery: taking a math problem, previously unknown, and working until it is solved. The teacher during this process plays the role of coach much like Urschell's coaches did. He writes: (the obstacles) "didn't stop my coaches from encouraging me to believe I could reach my goal and preparing and pushing me to work for it. When they told me, I had potential but would have to work hard, I listened." In Urschell's experience, he wants teachers to be more like his coaches and the productive struggle model is intended to achieve his goal.

Educational Routines (Tactical Delivery)

In the curriculum unit, lesson plans utilize three tactical delivery processes. They are: Which One Doesn't Belong, Noticing and Wondering and Three Act Math. Each is described below

Which One Doesn't Belong?

Which One Doesn't Belong? is an activity which allows students to share their thinking about the pictures presented without the fear of being wrong. Students decide which picture they believe does not belong and write down both their choice and the reason they have selected their choice. There is no wrong answer.

Noticing and Wondering

Educational research has shown that productive discourse and student conversation create opportunities for authentic learning and deep understanding. Noticing is a skill. Good problem solvers look at a problem and "notice" quickly, it is an automatic process for them. They then apply the ideas they gleaned by noticing and apply them to the problem. Seamlessly they solve the problem. Less experienced/skilled problem solvers read the problem and focus on just the question and what it is asking. As they attempt to solve the problem they try to remember "the right way," the "formula", "the prior lesson" required to solve it. They are not able to "notice" the details of the problem, use what they notice to trigger their prior math knowledge, the math already in their head, and then connect the math in the problem to the mathematical ideas they could use to move toward a solution. Using the "noticing and wondering" develops students into the "good problem solver" described above.

There are no right or wrong answers to the notices and wonderings therefore, every student has an equal entry point into the discussion. The discussion itself provides information to the whole class and can also provide the teacher an opportunity to dispel misconceptions and concept errors. The lesson can be extended further by student discussion or students completing their work and finding the solution to the problem.

Three Act Math

The Three Act Math method was introduced by Dan Meyer in 2010. The method is fully explained in a TED Talk entitled, "Math Class Needs a Makeover". The video presentation introduces the related classroom issues and the three-act method. In the TED talk, Dan identifies five harmful behaviors that he observes in his students and wants to change. They are

Lack of initiative

- Lack of perseverance
- Lack of retention

- Aversion to word problems
- Overeagerness for procedures and formulas

In the TED talk Dan emphasizes that students are taught to rely on the teacher, textbooks and workbooks when solving problems. He defines solving math problems as a multi-step, time-consuming process rather than a quick painless process. He encourages educators to emphasize the hard work and perseverance their students will need to develop in order to become skilled problem solvers. He compares the instantaneous quick solution process to TV sit-coms, microwaves and other instant result situations typical in today's society and believes that it develops an intolerance for uncertainty and encourages students to shut down as soon as they start to struggle and to wait to be rescued or given further instructions.

To combat intolerance for uncertainty, Dan suggests teachers of mathematics set the following goals:

- Use multimedia
- Encourage student intuition
- Ask the shortest question you can
- Let students build the problem
- Be less helpful

Classroom Activities

Lesson 1

Part 1 Which one doesn't belong? (Teddy Bear warm-up)

Objective: The objective of this lesson is to establish the general routine for "which one doesn't belong?". Students will practice making selections, justifying their choice and having discussions without any right or wrong answers.

Instructional Routine

Class Set-up

1. Give each student a recording sheet or ask students to turn their notebooks to a clean sheet of paper – they will record their answer and reason for the selection on the paper.
2. Describe the format of what the students will see on the board – 4 parts, upper and lower placement, bottom right, upper left as descriptors, etc.

3. Hand out or project the four-square image of teddy bears that students must respond to. Ask which one doesn't belong?

Individual Time to Think

4. Give students some time to look at their own before talking with others.
5. Students should write 1 thing that they believe doesn't belong and the reason they selected it.

Brainstorm More in Pairs

6. If there is time, ask students to talk in pairs about what they selected. Ask them to take notes on each other's answers.

Group Share

7. Bring students together for a large group conversation. Take notes on the board columns. You might say, "You're the brain and I'm the hand. Tell my hand what to write." Take notes without evaluating.

Discussion, ask "What do you select?"

8. Pause to let as many students as possible raise their hands. Call on students and record their answers at the front of the room.
9. As you record students' thoughts, thank or acknowledge each student equally. Record all student suggestions. Avoid correcting, praising, restating, clarifying, or asking questions. Avoid evaluating statements. They are the brain; you are the hand.

Part 2 Which one doesn't belong? (Algebraic Functions and Graphs)

Objective: The objective of this lesson is to discuss different representations of algebraic functions and their graphs, data and equations.

Instructional Routine

Class Set-up

1. Give each student a recording sheet or ask students to turn their notebooks to a clean sheet of paper – they will record their answer and reason for the selection on the paper.
2. Describe the format of what the students will see on the board – 4 parts, upper and lower placement, bottom right, upper left as descriptors, etc.
3. Hand out or project the four-square image of functions that students must respond to. Ask which one doesn't belong?

Individual Time to Think

4. Give students some time to look at their own before talking with others.
5. Students should write 1 thing that they believe doesn't belong and the reason they selected it.

Brainstorm More in Pairs

6. If there is time, ask students to talk in pairs about what they selected. Ask them to take notes on each other's answers.

Group Share

7. Bring students together for a large group conversation. Take notes on the board columns. You might say, "You're the brain and I'm the hand. Tell my hand what to write." Take notes without evaluating.

Discussion, ask "What do you select?"

8. Pause to let as many students as possible raise their hands. Call on students and record their answers at the front of the room.
9. As you record students' thoughts, thank or acknowledge each student equally. Record all student suggestions. Avoid correcting, praising, restating, clarifying, or asking questions. Avoid evaluating statements. They are the brain; you are the hand.

Next steps: Work with the class to identify different representation for data. Select equations and graphs for the function you are studying. Have students create their own 4 square problems using 4 different representation of the data (Which one doesn't belong?)

Lesson 2

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Noticing and Wondering Climate Change

Maps of Philadelphia before flooding and after flooding due to climate change. (see handouts in the appendix)

Notice and Wonder Instructional Routine

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Class Set-up

1. Give each student a recording sheet with 2 columns – one to list what the notice, the other for listing what they wonder (see example in appendix).
2. Hand out or project a graph, image, description of a situation (no questions), table of data, etc. Ask students to consider these two questions: *What do you notice? What do you wonder?*

Individual Time to Think

3. Give students some time to look at their own before talking with others.
4. Students should write at least 2 things they notice and 2 things they wonder.

Brainstorm More in Pairs

5. If there is time, ask students to talk in pairs about what they notice (what stands out to them) and what they wonder (what questions they have)? Ask them to take notes on each other's noticings and wonderings. Challenge them to think of at least one new question they didn't have before.

Group Share

6. Bring students together for a large group conversation. Take notes in two columns. You might say, "You're the brain and I'm the hand. Tell my hand what to write." Take notes without evaluating.

Discussion, ask "What do you notice?"

7. Pause to let as many students as possible raise their hands. Call on students and record their "noticings" at the front of the room.
8. As you record students' thoughts, thank or acknowledge each student equally. Record all student suggestions. Avoid correcting, praising, restating, clarifying, or

asking questions. Avoid evaluating statements. They are the brain; you are the hand.

Discussion, ask students, “What are you wondering?”

9. Pause to let as many students as possible raise their hands. Call on students and record their wonderings at the front of the room. Write questions down without answering them.
10. Ask students, “Is there anything up here that you are wondering about? Anything you need clarified? Do you have a question about something someone noticed or wondered?” If you or the students have questions about any items, ask the students who shared them to clarify them further.

Lesson 3

3 Act Math What do you Notice? What do you wonder?

Act 1 Videos of Schuylkill river running

Video of smokestacks

Video of plastic islands in the ocean

What do you notice, what do you wonder (what will the problem ask you to find? what data do you need in act 2 to answer the question?)

Act 2 Provide data students determine they need when they “wonder”

How much did the water temperature change? Will Philadelphia be underwater?

What can you do? What will you decide about global warming? How will you change? What will you advocate for in Philadelphia (separate project)?

Resources

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Brian Black and Michael Chiarappa. *Nature's Entrepot.* {excerpts}

Amitav Ghosh, *The Great Derangement.* {excerpts}

S Eben Kirksey, Nicholas Shapiro, Maria Brodine, "Hope in Blasted Landscapes"

Ruth Wilson Gilmore, "Forgotten Places and the Seeds of Grassroots Planning"

Bethany Wiggin, "Forgotten Places and Radical Hope on Philadelphia's Tidal Schuylkill River"

https://www.schuylkillbanks.org/explore

www.schuylkillcorps.org

William Cronon, "The Trouble with Wilderness, or, Getting Back to the Wrong Nature"

David R. Boyd, *The Rights of Nature* {excerpts}

Jeff Goodell, *The Water Will Come* {excerpts}

Elizabeth Rush, *Rising: Dispatches from the New American Shore*

Surging Seas Mapping Choices

Surging Seas Energy Infrastructures

Toxic-City, A climate Change Narrative

James Engell, "Climate Disruption Involves All Disciplines"

Anna Tsing, *The Mushroom at the End of the World* {excerpts}

Deborah Bird Rose and Thom van Dooren, "Keeping Faith with Death: Mourning and De-Extinction"

Donna Haraway, *Staying with the Trouble* {excerpts}

www.schuylkillcorps.org

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Bibliography for Teachers

Schwols, Amitra, and Kathleen Dempsey. Common Core Standards for High School Mathematics : A Quick-Start Guide, edited by John Kendall, Association for Supervision & Curriculum Development, 2012. ProQuest Ebook Central, https://ebookcentral-proquest-com.proxy.library.upenn.edu/lib/upenn-ebooks/detail.action?docID=1106832.

This book outlines the Common Core Standards for High School Mathematics and provides an overview and recommendations for teaching math.

Student Reading List

Classroom Materials

Appendix

PA Common Core Standards – Algebra 2

The PA Common Core Standards for Algebra 2 are listed below. In this curriculum Unit students will analyze data and write new functions given data in order to create mathematical models.

PA Common Core State Standard – Mathematics, Algebra 2
CC.2.2.HS.C.2 Graph and analyze functions, and use their properties to make connections between the different representations
CC.2.2.HS.C.3 Write functions or sequences that model relationships between two quantities
CC.2.2.HS.C.5 Construct and compare linear, quadratic, and exponential models to solve problems
CC.2.2.HS.C.6 Interpret functions in terms of the situations they model.

21st Century Learning

1. Make it relevant
2. Teach through the disciplines
3. Develop thinking skills
4. Encourage learning transfer
5. Teach the student how to learn
6. Address misunderstandings directly
7. Treat teamwork like and outcome
8. Exploit technology to support learning
9. Foster creativity

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Eight Effective Mathematics Teaching Practices

Source: National Council of Teachers of Mathematics. (2014). Principles to actions: Ensuring mathematical success for all. Reston, VA: Author.

1. Establish mathematics goals to focus learning.

   Effective teaching of mathematics establishes clear goals for the mathematics that students are learning, situates goals within learning progressions, and uses the goals to guide instructional decisions.

2. Implement tasks that promote reasoning and problem solving.

   Effective teaching of mathematics engages students in solving and discussing tasks that promote mathematical reasoning and problem solving and allow multiple entry points and varied solution strategies.

3. Use and connect mathematical representations.

   Effective teaching of mathematics engages students in making connections among mathematical representations to deepen understanding of mathematics concepts and procedures and as tools for problem solving.

4. Facilitate meaningful mathematical discourse.

   Effective teaching of mathematics facilitates discourse among students to build shared understanding of mathematical ideas by analyzing and comparing student approaches and arguments.

5. Pose purposeful questions.

   Effective teaching of mathematics uses purposeful questions to assess and advance students' reasoning and sense making about important mathematical ideas and relationships.

6. Build procedural fluency from conceptual understanding.

   Effective teaching of mathematics builds fluency with procedures on a foundation of conceptual understanding so that students, over time, become skillful in using procedures flexibly as they solve contextual and mathematical problems.

7. Support productive struggle in learning mathematics.

   Effective teaching of mathematics consistently provides students, individually and collectively, with opportunities and supports to engage in productive struggle as they grapple with mathematical ideas and relationships.

8. Elicit and use evidence of student thinking.

Effective teaching of mathematics uses evidence of student thinking to assess progress toward mathematical understanding and to adjust instruction continually in ways that support and extend learning.

Standards for Mathematical Practice (SMP's)

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure
8. Look for and express regularity in repeated reasoning.

Five Practice for Orchestrating Productive Math Discussions

Margaret S. Smith & Mary Kay Stein, NCTM & Corwin Press, 2011 www.nctm.org

1. Anticipating • Do the problem yourself • What are students likely to produce? • Which problems will most likely be the most useful in addressing the mathematics?

2. Monitoring • Listen, observe, identify key strategies • Keep track of approaches • Ask questions of students to get them back on track or to think more deeply

3. Selecting • CRUCIAL STEP – what do you want to highlight? • Purposefully select those that will advance mathematical ideas

4. Sequencing • In what order do you want to present the student work samples? • Do you want the most common? Present misconceptions first? • How will students share their work? Draw on board? Put under doc cam?

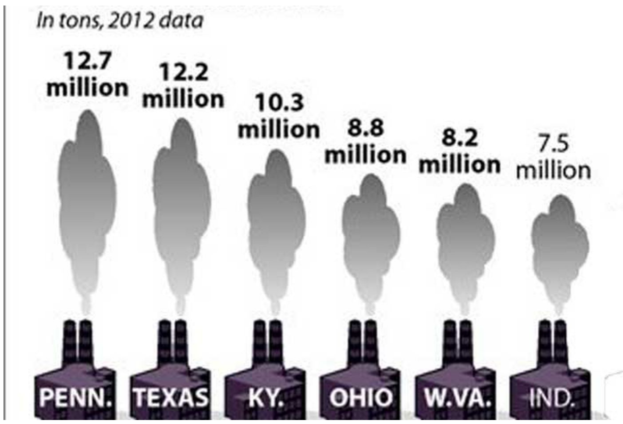
5. Connecting • Craft questions to make the mathematics visible. • Compare and contrast 2 or 3 students' work – what are the mathematical relationships? • What do parts of student's work represent in the original problem? The solution? Work done in the past?

Lesson Plan Handouts

Images for PowerPoint/Smartboard Slides

Philadelphia Maps

Largest US Coal Ask Finds – Pennsylvania Tops the List



With huge coal ash fines, Feds put coal industry on notice
The largest producer of the toxic substance: Pennsylvania
by Lisa Song, INSIDE CLIMATE NEWS, Posted: May 21, 2015
Philadelphia Inquirer,

Lesson 1 - Student Recording Sheet – Noticing and Wondering

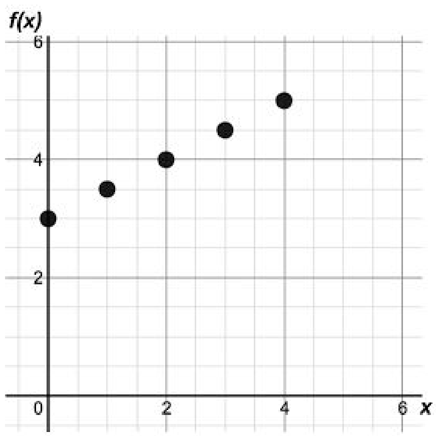
Name: ___________________________________

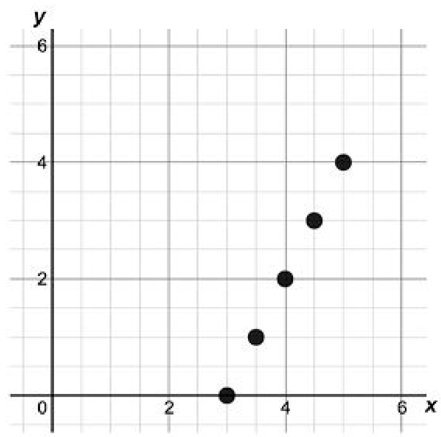
Noticed	Wondered

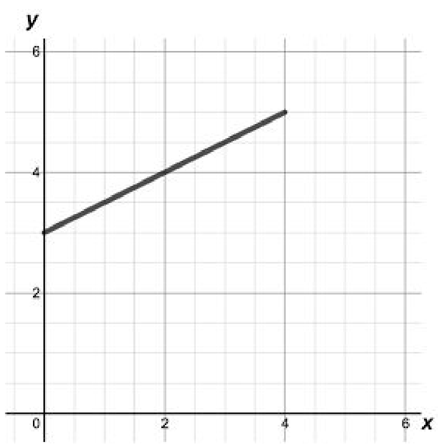
Lesson Plan 1 – Which One Doesn't Belong? Handout #1 or Projection #1

Teddy Bears - Which One Doesn't Belong?

Lesson Plan 1 – Which One Doesn't Belong? Handout #2 or Projection #2



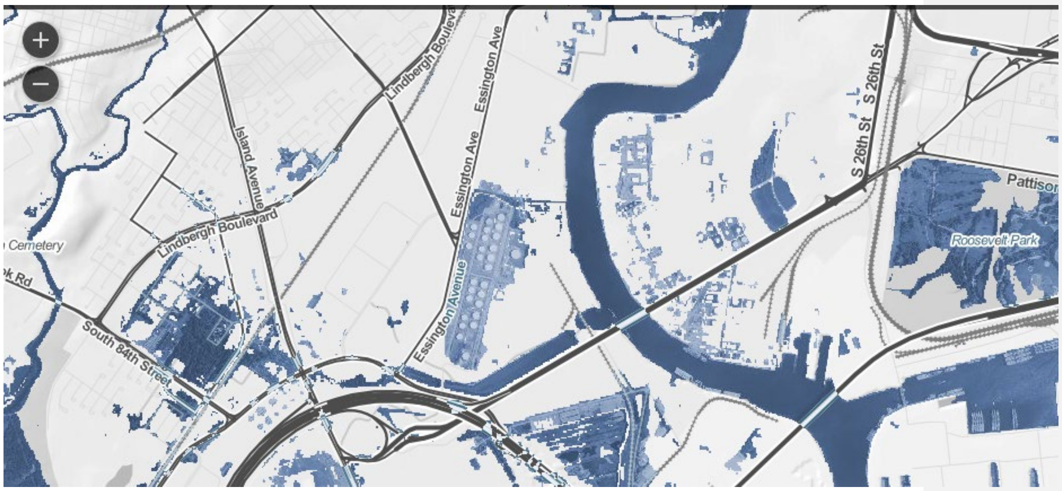


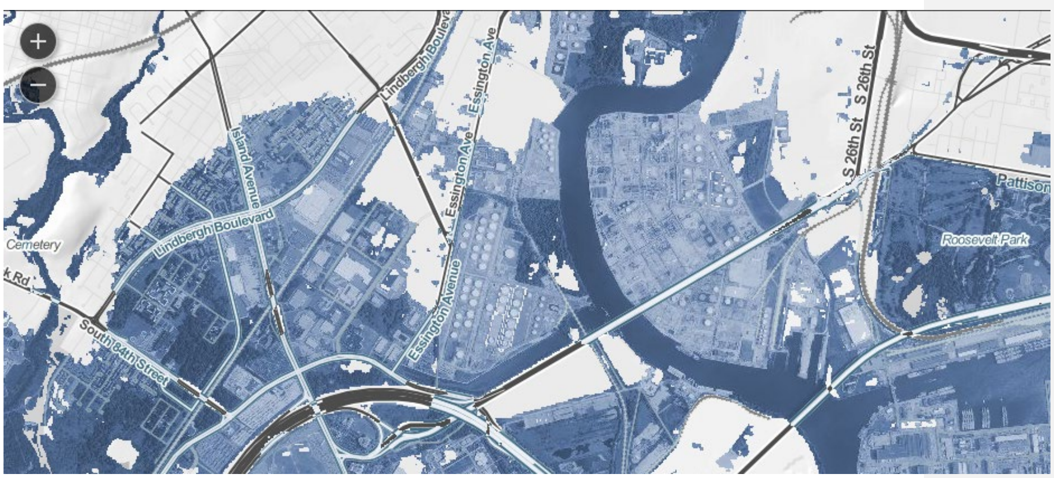


x	y
0	3
1	3.5
2	4
3	4.5
4	5

from Michael Rubin

Lesson Plan 2 – Handout #1 What Do You Notice? What Do You Wonder?





Lesson Plan 2 – Handout #2 Temperature Data

Monthly data – Yearly Precipitation by month

(Best Source: National Weather Service? Weather underground?

Abstract

In my seminar, Environmental Humanities from the Tidal Schuylkill River, we discussed issues along the lower, tidal, Schuylkill River as well as the relationship the river shares with larger issues including citizens and neighborhood development, global warming and climate change. Some of the specific course content as outlined in the syllabus were: Who has a right to the Schuylkill? Does the river itself have rights? How do our own vantagepoint informs how we understand the river? How does this location shape our conceptions of the global processes, systems, and challenges? I have utilized seminar material about the Schuylkill to create high school math lessons emanating from our discussions on the effect that global warming and climate change are predicted to have on the land surrounding the Schuylkill River and the City of Philadelphia and what we, the citizenry, can do about it. Students “notice”, “wonder” and then “discover” the math related to climate change along the Schuylkill River in Philadelphia.

Keywords

Climate change, Philadelphia, mathematics, Schuylkill River, Algebra