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| Title  | Volume of the Quabbin Reservoir **(*65 minute lesson)*** |
| Date | August 19, 2016 |
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| Subject AreasGrade Level | * Visual Arts
* Chemistry
* Math
* ELA **Grade 8**
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| Content Curriculum Frameworks addressed in this lesson | Indicate each content CF with its number and details.* ELA.W.8.3D: Use precise words and phrases, relevant descriptive details, and sensory language to capture the action and convey experiences and events.
* Physical Science PS3 (Chemistry): Recognize that the measurement of volume and mass requires understanding of the sensitivity of the measurement tools… and knowledge and appropriate use of significant digits.

 * Math 8.EE.4. Perform operations with numbers expressed in scientific notation, including problems where both decimal and scientific notation are used. Use scientific notation and choose units of appropriate size for measurements of very large or very small quantities (e.g., use millimeters per year for seafloor spreading). Interpret scientific notation that has been generated by technology.
* Visual Art:Cn10.1.8a Make art collaboratively to reflect on and reinforce positive aspects of group identity.
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| Specific Technology Standards addressed in this lesson | **ISTE Teacher Standards:**1. **Facilitate and inspire student learning and creativity**: Teachers use their knowledge of subject matter, teaching, and learning, and technology to facilitate experiences that advance student learning, creativity, and innovation in both face-to-face and virtual environments.3. **Model digital age work and learning**: Teachers exhibit knowledge, skills, and work processes representative of an innovative professional in a global and digital society.4. **Promote and model digital citizenship and responsibility**: Teachers understand local and global societal issues and responsibilities in an evolving digital culture and exhibit legal and ethical behavior in their professional practices. **ISTE Student Standards:****ISTE.2:** Students use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others.**ISTE.2.B:** Communicate information and ideas effectively to multiple audiences using a variety of media and formats. **MA State Standards: G6-8:****Standard 1:** Demonstrate proficiency in the use of computers and applications, as well as an understanding of the concepts underlying hardware, software, and connectivity.**Standard 3:** Demonstrate the ability to use technology for research, critical thinking, problem solving, decision making, communication, collaboration, creativity, and innovation. |

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| **Learning Targets and Assessments** |
| * I can evaluate the volume of the Quabbin reservoir using scientific notation and critical thinking skills.
* I can determine the appropriate significant figures to use.
* I can make personal connections and find creative solutions by working collaboratively on a sculpture.
* I can make personal connections to the Quabbin using relevant descriptive detail and sensory imagery.
 | **Assessments FOR Learning (formative – during the lesson)*** During the math section students will be observed while working and check in with thumbs up and thumbs down.
* Students will be able to rewrite the trillions of cubic inches of water into scientific notation. They will be able to divide and calculate the number of structures that correspond to their given fill volume of the Quabbin Reservoir.

**Assessments OF Learning (summative - exit)*** During writing prompt students will be evaluated on whether they made a personal connection and used the descriptive details of the ELA standard.
* Math Worksheet/Graphic Organizer: Students will complete the worksheet which will end with a space for their final answer of the number of sculptures/ structures that will fit into their given volume of the Quabbin. These answers will be written in scientific notation with consideration of significant figures.
* Understanding of significant figures will be evaluated based on student responses in the worksheet for math calculations.
* Students will complete an exit ticket: Using Poll Everywhere, they will answer the question, “Based on the volumes you have been working with during this lesson, do you think the Quabbin will continue to be a sustainable source of potable water in the future? You might consider global climate change/drought, population increases, and acid rain.”
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There are three phases to this lesson:

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| **INTRODUCTION of the lesson: Building engagement/setting purpose/activating prior knowledge….** |
| **Instructional Steps** | **Differentiation** |
| *PRIOR KNOWLEDGE: Students will have visited the Quabbin, studied its overarching story and history, and have some knowledge of how vast and sustainable it is. Students will also have an understanding of scientific notation and significant figures so that the handouts they will receive are primarily tools for review. Students also have understanding of how to divide and that we subtract exponents when we are dividing.*At the start of the lesson, students will break into new groups, preferably of five or fewer students. They will be provided with strips of colored paper at their tables. Teacher will prompt students to write on a strip of paper about a personal connection they made to the Quabbin, either from seeing the Quabbin in person or from any of the information they learned from the historic society, photos, or audio files (this is like a text-to-self connection) Students will have the opportunity to share their responses **(10 minutes).** *\*\*These reflections will be used later in the unit to qualify students’ growth in their understanding of the Quabbin from the beginning to the end of the unit.*Once the class has finished the writing exercise, the teacher will provide each student with the Creative Sculpture Guidelines and Rubric handout. Groups will work collaboratively for 12 minutes to connect 5 wiffle balls with wire in a creative way, considering the list of guidelines and the rubric of guidelines for construction, collaboration and creativity provided. After the teacher gives instructions, one person from each group will pick up a bag of art materials containing 5 wiffle balls and 40 pipe cleaners (or pieces of wire). These materials will be shared at each table with the group of students. Half way through the students’ work time, students will be stopped briefly and provided with additional materials to make the sculptures unique (Sharpies, tape and stickers). The teacher will also announce half way through the additional challenge of finding a creative way to incorporate their written response papers into the sculpture. They can roll, fold or crumple the paper and connect with their wire or tape. When construction time is complete, students will do a “gallery walk” around the room to see the whole class’s sculptures. They will help cleanup extra art materials before the next section. **(20 minutes total)** *\*\*The construction of sculptures/structures in this group atmosphere builds their group identity as they will move through the unit and will have many opportunities to do further research and activities about the Quabbin with these particular group members.* | This part of the lesson differentiates for kinesthetic and visual-spatial learners. Before delving into math calculations, the students have a physical object they have made themselves to concretize the concept they are working with. |

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| **Scaffolding plans for the BODY of the instruction** |
| **Instructional Steps** | **Differentiation** |
| Students will work in their small groups to find the number of wiffle ball sculpture/structures they just created (in the form of scientific notation) that will fill the Quabbin reservoir at a given volume. Each group will be given the volume of the Quabbin at varying levels of capacity collected from the Massachusetts Water Resources Authority’s online data table. *\*\*The answers they come up with will be used and compared in subsequent lessons surrounding the Quabbin’s capacity and volume.*Since converting the varying volumes of the Quabbin from gallons to cubic inches and finding the volume of the wiffle ball structure is not the main focus of this lesson, those figures will be pre-calculated and given to the students.**Section 1:**First, students will receive a handout explaining how to understand significant digits/figures and a second handout explaining scientific notation. Teacher will review the handout and ask for questions/lack of understanding. Students will then put into practice their understanding of significant digits/figures and scientific notation through the math lesson. Students will be assessed on their understanding of significant digits at the same time as their grasp of the math skills by student responses on the worksheet. **(10 minutes)****Section 2:**Students will be reminded of their prior knowledge about the volume of the Quabbin at its capacity (412 billion gallons) and that it is not a sustainable source of potable water if its volume is reduced to 80% of its capacity. Each group will receive a note with the volume of their wiffle ball structure and their assigned volume of the Quabbin. Volume can be pre-calculated by the teacher based on the figures from the Massachusetts Water Resource Authority’s website. <http://www.mwra.state.ma.us/monthly/wsupdat/archivequabbinlevels.htm> *\*\* See end of lesson plan for more specific instructions on how to do the pre-work, with our process as an example.*Students will receive a graphic organizer with a step by step breakdown of how to calculate the number of wiffle ball structures that will fill their particular volume of the Quabbin with space to show work beside each step. Students will be walked through this portion of the lesson by a video made through iMovie. The video will demonstrate how to divide two figures in scientific notation using a sample value for the volume of the Quabbin, but the same volume of the wiffle ball structure. After each step of calculations is shown in the video, students will be given 2 minutes to complete that step. Students will have a chance to work as a group to complete their individual graphic organizers and teachers will circulate to check for understanding and scaffold where necessary. *\*\* They may use a calculator/ phone app to aid in this work. Teacher may stop and start the video as necessary, but it is built to be approximately 12 minutes long including the 2 minutes provided for each calculation. Also, the video’s sound can be heard, but may be quieter than expected, so students should keep their voices down so they can hear it as much as possible. Teacher may also mute the volume and narrate over with their own explanation if they would like to use different language that would be more beneficial for their learners.***Section 3:**Finally, the last step of their graphic organizer will be to fill in the number of structures they found, in scientific notation and significant digits/figures, that will fill their volume of the Quabbin. Each student’s sheet will be collected as a formative assessment for their understanding and a summative assessment for their completion of the exercise to inform how we plan our next lesson when we use this data they found further. **(20 min for Sections 1-3)** | We will differentiate for students’ comfort with group work by allowing students to either solve the math problem with their group members or solve the problem on their own.We are differentiating for various readiness levels by providing graphic organizers to help students with lower readiness levels organize their ideas. We are differentiating for both interest and readiness levels by allowing students to use the calculators on their phones if they need to. Students who want more of a challenge can solve the problem on paper. Young people (especially our 8th graders!) tend to find technology inherently engaging.We are using heterogeneous grouping by putting the stronger math students in different groups. These students will be able to help their classmates.We are differentiating for various learning styles by using the UDL concept of multiple pathways to the same knowledge. For instance, teacher will give students a handout about significant digits and explain the same concept verbally. The Google Slideshow will present written information that is also being spoken by the presenters. We will share the slideshow with students so that they can review slides if they need to.We are differentiating instruction by providing the math lesson through a video, therefore freeing us up to circulate through the classroom and scaffold students’ learning. The video provides approximately four 1 minute video clips walking through a sample problem on the same graphic organizer students will be using, followed by 2 minutes of a screen with just the particular question they should be working on after each section. This will maintain our time management and will give students a structured timeframe to work independently or alone while moving through the graphic organizer.  |

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| **END Synthesis: How will students synthesize their understanding?**  |
| **Instructional Steps** | **Differentiation** |
| Teacher will have students fill out a brief exit ticket using Poll Everywhere, answering the question, “Based on the volumes you have been working with during this lesson, do you think the Quabbin will continue to be a source of potable water in the future? You might consider global climate change/drought, population increases, and acid rain.” **(5 minutes)** | This section differentiates for student engagement by asking them to use technology in the classroom. It creates an engaging atmosphere because, rather than answering their exit tickets in isolation, students can view each other’s answers on the projector. |

Please include information on each of the following:

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| **Materials Required for this lesson (complete list and each document or item typed up)**Wiffle Balls Computer and Projector for video and slideshowSheets of paper Computer/Projector for video and slideshowPencils Collaborative Sculpture Project Guidelines/RubricPermanent Markers Volume Calculations Graphic OrganizerWire or Pipe Cleaners Significant Figures & Scientific Notation WorksheetsTape (as time allows) Quabbin Volume Math VideoStickers (as time allows) Google Slideshow and Google Form |
| **Social Justice Orientation** The Quabbin Reservoir is a critical source of drinking water for Boston and other areas, including South Hadley. Various factors, including weather conditions, maintenance of watershed, and human use, influence how much water is in the Quabbin at any given time. Our lessons will have students consider the various levels of water in the Quabbin over the past few years versus the 80% threshold for the Quabbin to remain a sustainable water source compared to the (100%) capacity. In our lesson, we will make this connection between water levels and the sustainability of potable water. At the end of our presentation, we will discuss these ideas explicitly. We will ask students to fill out an exit ticket which asks, “Based on the volumes you have been working with during this lesson, do you think the Quabbin will continue to be a source of potable water in the future? You might consider global climate change/drought, population increases, and acid rain.” |
| **Human Development – Age appropriate learning and activities – elaborate on how you selected the activities and how you know they are age appropriate**All activities and lessons were built around the Math, Science, Art, and ELA standards for 8th grade students. It is developmentally appropriate to have the students work in groups because, according to Piaget and Vygotsky’s developmental theories, knowledge is created through social interactions (co-constructionists). Students learn best when they interact with their peers to acquire knowledge. Additionally, by solving the problem themselves, students can come to a more deep understanding of knowledge than if they passively receive information from the teacher. By placing students in groups where the individuals vary in ability, we are capitalizing on Vygotsky’s ideas of Zone of Proximal Development and less advanced students learning from more advanced students.Having the students decorate wiffle balls gives them an opportunity to express their identities and perhaps engage in self-reflection about how they view themselves. This is an appropriate activity for adolescents because they are going through the “Identity Formation vs. Role Confusion” stage in Erik Erikson’s model of human development.Having an interdisciplinary lesson is a “brain-friendly” learning practice because the brain wants to make connections between different things the student is learning. The compartmentalization of academic subjects is not as conducive to the synthesis of knowledge and the creation of synaptical connections as interdisciplinary learning.The social justice/exit ticket section of our lesson plan asks students to engage in moral reasoning insofar as they are considering the effects that human activities can have on other people’s access to potable water. Implicit in the conclusion of our lesson is the idea that as consumers of water, we have a moral obligation to preserve water for posterity. According to Lawrence Kohlberg, it is developmentally appropriate for students to engage in this level of moral reasoning at this age. When students are under 9 years old, they understand that morality in terms of whether or not they will be punished for a behavior; but by adolescence they are capable of conventional moral reasoning.Working in groups requires students to develop their social skills, which they are particularly primed to do by 8th grade. Adolescents experience an increase in white matter in their frontal lobes (which oversee social, emotional, and executive functionings), which allows them to improve their social skills. Students are in a good place developmentally to develop empathy and conflict-resolution skills.By concretizing the lesson with an art project (giving the students a visual/ spatial understanding of the math concepts we are using) we are increasing the chances that the students will develop a better understanding of the content. Rather than having students engage in rote memorization of math formulas, we are having them learn about volume in an authentic context.We are activating students’ schema about the Quabbin by having them reflect on their past experiences of the reservoir. By activating background knowledge, we help students to open up the mental “folders” that contain information about the Quabbin. This will prep them to engage deeply with the Quabbin in the art project and math lesson. Their familiarity with the Quabbin will also provide an access point for the math for students who might be less comfortable with the calculations because the exercise starts with something they understand really well. |
| **Technology Integration – write a paragraph on how the technology in this lesson enhanced the learning of the students.** We are integrating technology into our lesson in multiple ways. Before the lesson, we are having the students fill out a Google Form survey to help us organize them into groups with people they have not collaborated with yet. The teacher is using Google Sheets to analyze the data from the form to organize the class into six groups of five. We use Google Slides to present information to the entire group. The teacher documents each group’s sculpture and writing responses with her camera. After the lesson she will upload the photos into a group photo album. We will record the math lesson on video and edit it to instruct students so that the teachers can meander through the room, providing help as needed. We also used Daum Equation Editor to assist in writing portions of the graphic organizer in mathematical notation. Lastly, we will end the lesson with an exit poll that the students will fill out through Poll Everywhere, either on their phones, computers, or tablets. |
| **Social Emotional Learning – write a paragraph about how you have included process or activities that speak to the ‘heart’ rather than simply content – the head!** To help students feel more comfortable interacting with cohort members that they do not know very well, we are intentionally creating groups based on participant feedback in which each person has at least one person they have not worked with yet. Our art project encourages them to think of themselves as a team when they collaborate to combine their wiffle balls. It also provides a structured way for them to interact with and get to know people they may not know very well. The writing aspect of the introductory activity asks the students to make personal connections to the Quabbin which works on their intrapersonal/ reflective skills. |

Each group’s has been calculated based on the figures from the Massachusetts Water Resource Authority’s website.

<http://www.mwra.state.ma.us/monthly/wsupdat/archivequabbinlevels.htm>

The following figures were used:

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| **Date** | **Elevation (ft)** | **Volume (million gallons)** | **Capacity (%)** |
| 03/01/05 | 527.40 | 392,140 | 95.1 |
| 11/01/07 | 524.07 | 367,125 | 89.1 |
| 04/01/10 | 530.56 | 416,997 | 101.2 |
| 03/01/12 | 529.01 | 404,478 | 98.1 |
| 02/01/13 | 522.78 | 357,450 | 86.7 |
| Not on table | Not on table | 329,600 | 80 |

To convert gallons to cubic inches, multiply by 231 in3/1 gallon. (This is the conversion factor between gallons and cubic inches.)

The  was calculated from the figure found on Top End Sports website. (This is assuming the the number given in inches is the diameter of the wiffle ball.)

Use the standard equation to find the volume of a sphere: 

NOTE: This does not account for the ball being hollow or the pipe cleaners. <http://www.topendsports.com/resources/equipment-ball-size.htm>