Is Technology Destroying Earth?

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Overview

This unit is designed for students currently enrolled in a High School Chemistry course, mostly those in 11th grade, though students in grades 10-12 are occasionally rostered to the class. It is designed for 90-minute class periods that meet 5 days a week. While this unit is to be conducted within a Chemistry classroom, it has an overarching Environmental science theme.

This unit will allow students to gather information from top environmental websites located in a database at the World Organization website. Students will work in groups of 3-5 students to investigate the chemical reactions associated with advances in agriculture, transportation, health care, communication and waste products. This unit is setup to inform students of the harmful effects of technological advancement, spur investigation of potential solutions and then disperse the information to other humans.

Rationale

High school students at my comprehensive high school in Philadelphia often do not make the connections between their own lives and their surrounding environment. My curriculum unit on this topic explores how lives across the globe are currently being affected by localized environmental issues caused by human influenced chemical reactions. We will also look into the future to predict how our lives could be affected as these chemical reactions make a broader impact on the global environment.

Background Information

From the earliest forms of agriculture to the latest technologies, all human activity has drawn on natural resources and has had both short- and long-term consequences, positive as well as negative, for the health of both people and the natural environment. These consequences have grown stronger in recent human history. Society has changed dramatically, and human populations and longevity have increased, as advances in science and engineering have influenced the ways in which people interact with one another and with their surrounding natural environment. Not only do science and engineering affect society; society's decisions (whether made through market forces or political processes) influence the work of scientists and engineers. These decisions sometimes establish goals and priorities for improving or replacing technologies; at other times they set limits, such as in regulating the extraction of raw materials or in setting allowable levels of pollution from mining, farming, and industry (NRC, 2012, p. 212).

Starting with our ancestors and their control of fire, humans have continuously innovated by using materials found in our environment. Our utilization of science and technology separates us from every other life form. Advances in agriculture, transportation, health care, and communication have created desired technological effects along with unexpected environmental outcomes. As we pillage our environment for resources for technological advancement, we adjust our environment. Our effect has been so great that some scientists propose we have entered another geologic age of our own making.

In 2002, chemist Paul Crutzen of the Max Planck Institute for Chemistry in Mainz, Germany, utilized the term Anthropocene to reason that human impact is altering the Earth to the point that a new epoch is emerging. Anthropocene (AN-throh-puh-seen) combines the Greek words for *human* and *new*. This term suggests that human actions determine the behavior of the planet Earth to a greater degree than other natural processes.

More and more evidence is amounting to support the claim that we have created a new age of the Earth where the negative impact of the human footprint ensures a gradual destruction of the Earth. "Man, the eroder" now transforms the atmospheric, geologic, hydrologic, biospheric, and other Earth system processes. Some of the key evidence is outlined below:

- Excessively rapid climate change, so that ecosystems cannot adapt
- The Arctic ocean ice cover is thinner by approximately 40% compared to 20-40 years ago
- Ice loss and the growing sea levels
- Overpopulation (fourfold increase in the 20th century alone)
- Increasing demand for freshwater
- Releases of NO_x into the atmosphere, resulting in high surface ozone layers

- Loss of agricultural soil through erosion
- Loss of phosphorous leads to dangerous depletion in agricultural regions
- Melting supplies of phosphate reserves (leading to serious reduction in crop yield)

Objectives

The skill objectives students will meet are varied, but are typical of a high school chemistry course. Students will learn problem solving and estimation techniques as well as improve their ability to make arguments that are supported by evidence and data. To broaden the scope of this unit, I wanted to utilize the Next Generation Science Standards which can be found in the Content Standards section. As a side note, Pennsylvania has yet to adopt the Next Generation Science Standards.

The chemistry specific objectives of the unit will include the following:

- Students will symbolically represent chemical equations found in the environment.
- Students will predict the products of specific chemical reactions in the environment.
- Students will classify these chemical reactions as either synthesis, decomposition, single replacement, double replacement, or combustion.
- Students will balance the chemical equations by applying the Law of Conservation of Mass.
- Students will recognize common signs of chemical changes.

Strategies

Guided notes:

Guided Notes are teacher prepared handouts that have blank spaces for writing down key concepts, facts, definitions, etc. They allow students the opportunity to demonstrate appropriate classroom behavior while promoting active engagement during a lecture. Guided Notes can increase on-task behavior, improve note-taking accuracy and help improve academic performance. Guided Notes can easily be adapted to any instructional level and altered for students with specific skill deficits.

According to the handy Teacher Toolkit, there are 4 guidelines that allow for successful implementation of guided notes.

- Prioritize: Decide what is most important for students to understand in the presentation or reading for which they will be taking notes.
- Create: Prepare a set of notes that contains the essential information from the presentation or reading. Underline or highlight the key concepts, facts or information

that students will be responsible for writing into the final version. Next, replace those concepts with blanks for the students to fill in.

- Explain: Prior to handing out copies of the Guided Notes in class, ensure that students understand their responsibility to fill in each of the blanks with the appropriate concepts, definitions, or other content to help them understand what they will be seeing, hearing, or reading.
- Review: Discuss the correct answers with the class as the presentation progresses or after the reading.

Cooperative Learning:

Cooperative Learning is an instructional strategy in which groups of students work together on a common task. For this unit, groups of students will form cell phone brand corporations. Each group member is individually responsible for a specific part of the corporation. Researchers report that cooperation typically results in higher group and individual achievement, healthier relationships with peers, more metacognition, and greater psychological health and self-esteem (Johnson and Johnson 1989).

According to David Johnson and Roger Johnson (1999), there are five basic elements that allow successful small-group learning:

• Positive interdependence: Students feel responsible for their own and the group's effort.
• Face-to-face interaction: Students encourage and support one another; the environment encourages discussion and eye contact.
• Individual and group accountability: Each student is responsible for doing their part; the group is accountable for meeting its goal.
• Group behaviors: Group members gain direct instruction in the interpersonal, social, and collaborative skills needed to work with others.
• Group processing: Group members analyze their own and the group's ability to work together.

Problem-Based Learning:

The best way for students to learn science is to experience the problems and try to solve them. To do this, real-world problems are presented for students to investigate what they need to know and want to know. In a problem-based learning environment, students take responsibility for what is learned and how it is learned. The teacher guides the investigations through challenging questions and well-planned lesson structure, but the students use collaboration and inquiry to problem-find, problem-solve, and evaluate results. Problem-based learning is an instructional strategy in which students learn through solving problems and reflecting on their experiences (Barrows & Tamblyn, 1980).

Close Reading:
Close reading allows students to critically analyze text by focusing on vital details. Students read to determine what the text says so that they can make logical inferences from the information. Students are to cite specific textual evidence when writing or speaking to support conclusions drawn from the text.

According to National Board Certified Teacher Beth Burke, close reading includes:

- Using short passages and excerpts
- Diving right into the text with limited pre-reading activities
- Focusing on the text itself
- Rereading deliberately
- Reading with a pencil
- Noticing things that are confusing
- Discussing the text with others
    - o Think-Pair Share or Turn and Talk frequently
    - o Small groups and whole class
- Responding to text-dependent questions

Classroom Activities

Lesson One: Man vs. Earth
Objective: • Students will describe accelerating global change and the factors that contribute to it. Materials: • YouTube Video – "Man vs. Earth" • Computer – 1 per group • Worksheet – Individual Anthropocene Trend – 1 per student • Infographic – "Timeline: Modern Revolution" Do Now: • "Man vs. Earth" video will be played. Students have 3 minutes to free write in order to reflect on the video. Instruction: • Students will pair up and share their reflections. • Activity: The Appetite for Energy displayed on front board and gone over verbally in a full class discussion. • Watch: "Threshold 8: The Modern Revolution" (Big History Project Website) • Teacher Lecture: Infographic Displayed "Timeline: Modern Revolution" as teacher

briefly lectures on key points throughout history, focusing on scientific discoveries and technological advancement.

- Students will then work in groups of 2 or 3 (depending on class size) to dissect two trends that the teacher has already randomly pre-selected and paired for each group which can be found on the "Welcome to the Anthropocene" website. The direct link for the trends are located here: http://www.anthropocene.info/great-acceleration.php Students are to complete the Individual Anthropocene Trend worksheet.

Homework:

- Review your Anthropocene Trend Worksheet as you will be explaining your trends to your classmates tomorrow.

Exit Ticket:

- Do you think we have the resources to support the increasing energy usage?

Lesson Two: Anthropocene Day 1

Objective:

- Students will understand the key features that define the Anthropocene.

Materials:

- Worksheet – Compilations of Anthropocene Trends – 1 per student
- Video – "Crash Course: The Anthropocene and the Near Future"
- Article – "The Anthropocene" – 1 per group (different reading levels provided)
- Worksheet – Close reading "The Anthropocene" – 1 per group
- Vocabulary Challenge – 1 per student

Do Now:

- Take out your trends paper from yesterday. Make at least one connection between your socio-economic trend and your earth systems trend.

Instruction:

- Students from each group will separate and transfer information from the socio-economic and earth system trends to complete the Compilations of Anthropocene Trends worksheet.
- Teacher will then provide a preview of the video "Crash Course: The Anthropocene and the Near Future." The video will be stopped at points to go over key concepts.
- Watch: "Crash Course: The Anthropocene and the Near Future" (12 minutes)
- Teacher will stop video at specific points to review concepts and ask specific questions.

- After the video, teacher will ask students if they think the Anthropocene should be an official era in our history. Is it possible to name an era or really know what's happening when we're right in the middle of it? Students will complete a think-pair-share. Teacher will then provide a summary of the video
- Read: "The Anthropocene" Students will be broken down into reading groups based on reading level. They will utilize three close reads strategy and accompanying worksheet to help guide their understanding of the article. Once finished, the teacher will summarize the key points of the article.

Homework:

- Vocabulary Challenge

Exit Ticket:

- Do you think we will survive the Anthropocene?

Lesson Three: Anthropocene Day 2

Objective:

- Students will understand the key features that define the Anthropocene.

Materials:

- Article – "Anthropocene Africa: Out of Every Crisis, an Opportunity" – 1 per group (different reading levels provided)
- Worksheet – Close reading "Anthropocene Africa: Out of Every Crisis, an Opportunity" – 1 per group
- Activity – Population growth – 1 per student
- Essay – Impact of Population Growth – 1 per student

Do Now:

- Welcome to the Anthropocene video http://www.anthropocene.info/short-films.php Students have 3 minutes to free write in order to reflect on the video.

Instruction:

- Students will pair up and share their reflections.
- Read: "Anthropocene Africa: Out of Every Crisis, an Opportunity" Students will be broken down into reading groups based on reading level. They will utilize three close reads strategy and accompanying worksheet to help guide their understanding of the article. Once finished, the teacher will summarize the key points of the article.
- Class Discussion: Teacher will facilitate the class discussion.

- Activity: Population Growth - Students will individually study the human population graph and complete the accompanying questions. Then students will share their progress with other students.
- Essay explanation: Teacher will go over key components of the Essay and provide the Writing Rubric.

Homework:
- The Impact of Population Growth Essay

Exit Ticket:
- What is one benefit and one drawback of population growth?

Lesson Four: What are Chemical Reactions?

Objective:
- Students will identify chemical reactions in the environment.

Materials:
- Anthropocene Quiz (google form)
- Final Project Checklist
- Slideshow – Chemical Reactions
- Computer – 1 per group (more if available)

Do Now:
- Anthropocene Quiz

Instruction:
- Group Project – Teacher will explain the premise of the project with a culminating presentation due at the end of the unit. Students are to be pre-grouped in a heterogeneous manner. Students will be randomly assigned one of the Planetary Boundaries provided on the "Welcome to the Anthropocene" website. These Planetary Boundaries are as follows: land use change, biodiversity, climate change, novel entities, stratospheric ozone layer, atmospheric aerosol loading, ocean acidification, altered flows of nitrogen and phosphorus, and freshwater use.
- Guided Notes – Students will take guided notes on the teacher slideshow lecture.
- Students will then create their presentation with a title page (Checklist #1) and begin research on their Planetary Boundary assigned (Checklist #2).

Homework:

- The Impact of Population Growth Essay

Exit Ticket:
- What is a chemical reaction?

Lesson Five: A Closer Look at a Chemical Reaction

Objectives:
- Students will recognize common signs of chemical changes.
- Students will symbolically represent chemical equations found in the environment.
- Students will classify these chemical reactions as either synthesis, decomposition, single replacement, double replacement, or combustion.

Materials:
- Lab – A Closer Look at a Chemical Reaction (Materials listed on document)
- Computer – 1 per group (more if available)

Do Now:
- List the 5 types of chemical reactions gone over from the previous class.

Instruction:
- Lab – Students will conduct A Closer Look at a Chemical Reaction Lab
- Class Discussion on Analysis & Conclusion of the Lab
- Project – Students will identify reactions associated with their Planetary Boundary (Checklist #3)

Homework:
- The Impact of Population Growth Essay

Exit Ticket:
- How can you tell if a chemical reaction takes place?

Lesson Six: Changes in Color

Objectives:
- Students will recognize common signs of chemical changes.
- Students will predict the products of specific chemical reactions in the environment.

Materials:

- Lab – Changes in Color During a Chemical Reaction (Materials listed on document)
- Computer – 1 per group (more if available)

Do Now:

- A chemical reaction will be displayed on the front board. Students are to copy it down and label the products and reactants.

Instruction:

- Lab – Students will conduct Changes in Color During a Chemical Reaction Lab
- Class Discussion on Analysis & Conclusion of the Lab
- Project – Students will label reactants and products for each chemical reaction (Checklist #4)

Homework:

- The Impact of Population Growth Essay

Exit Ticket:

- The yield sign always points to the _____.

Lesson Seven: Changes in Temperature

Objectives:

- Students will recognize common signs of chemical changes.
- Students will balance the chemical equations by applying the Law of Conservation of Mass.

Materials:

- Lab – Changes in Temperature During Chemical Reaction (Materials listed on document)
- Computer – 1 per group (more if available)

Do Now:

- Balancing reaction problem

Instruction:

- Lab – Students will conduct Changes in Temperature During a Chemical Reaction Lab
- Class Discussion on Analysis & Conclusion of the Lab

- Project – Students will begin brainstorming (Checklist #5)

Homework:
- The Impact of Population Growth Essay

Exit Ticket:
- Balancing reaction problem

Lesson Eight: Production of a Gas

Objectives:
- Students will recognize common signs of chemical changes.
- Students will balance the chemical equations by applying the Law of Conservation of Mass.

Materials:
- Lab – Production of a Gas During a Chemical Reaction (Materials listed on document)
- Computer – 1 per group (more if available)

Do Now:
- Balancing reaction problem

Instruction:
- Lab – Students will conduct Production of a Gas During a Chemical Reaction Lab
- Class Discussion on Analysis & Conclusion of the Lab
- Project – Students will begin brainstorming (Checklist #6)

Homework:
- The Impact of Population Growth Essay

Exit Ticket:
- Balancing reaction problem

Lesson Nine: Production of a Solid

Objective:
- Students will recognize common signs of chemical changes.

Materials:

- Lab – Production of a Solid During a Chemical Reaction (Materials listed on document)

Do Now:

- Balancing reaction problem

Instruction:

- Lab – Students will conduct Production of a Solid During a Chemical Reaction Lab
- Class Discussion on Analysis & Conclusion of the Lab
- Project – Students will work together to research how their boundary is changing and any measures taken to correct this change (Checklist #7)

Homework: The Impact of Population Growth Essay

Exit Ticket:

- Balancing reaction problem

Lesson Ten: Presentations

Objective:

- Students will present their findings.

Materials:

- Student presentations emailed or uploaded through google classroom
- Presentation Rubric
- Content Presentation Rubric
- Self-Reflection on Learning

Do Now:

- Discuss with your classmates the order of the group presentations. Then signup on the front board for your group's time slot.

Instruction:

- Students will have no more than 10 minutes to present their projects.
- Teacher will utilize the presentation rubric and content presentation rubric in order to grade students.

Homework:
- The Impact of Population Growth Essay

Exit Ticket:
- Self Reflection on Learning

Annotated Bibliography/Resources

Reading List for Teachers

Burke, Beth. (n.d.) A Close Look at Close Reading: Scaffolding Students with Complex Texts. <http://nieonline.com/tbtimes/downloads/CCSS_reading.pdf>
Nice article that explains Close Reading

Diamond, Jared M. (2005). Collapse: How Societies Choose to Fail or Succeed. New York: Viking.
Amazing book that covers past civilizations that crumbled or survived.

Johnson D. W., & Johnson, R. (1989). Cooperation and competition: Theory and research. Edina, MN: interaction Book Company.
This book provides information about cooperative learning instructional strategy.

Johnson, D. W., & Johnson, R. (1999). Learning together and alone: Cooperative, competitive, and individualistic learning (5th Ed.). Boston: Allyn & Bacon.
This book provides information about cooperative learning instructional strategy.

Konrad, M., Joseph, L. M., & Eveleigh, E. (2009). A meta-analytic review of guided notes. Education and Treatment of Children, 32(3), 421-444.
This book provides information about guided notes instructional strategy.

NV atCEPImperial (2013) Climate Change in the Anthropocene <https://www.youtube.com/watch?v=6Bjn2RGAIo0>
If you prefer to acquire knowledge through a video, this is the best one I found.

Rockström, J., & Klum, M. (2014). Big world, small planet: Abundance within planetary boundaries. Bokforlaget Max Strom. < http://bwsp.org/ >
Amazing pictures are included in this powerful book that shows the importance of the environment to human survival.

Spilsbury, L., & Spilsbury, R. (2007). Chemical reactions. Chicago, IL: Heinemann Library.
This book provides background information on chemical reactions.

Vince, G. (2014). Adventures in the Anthropocene: A journey to the heart of the planet we made. London: Chatto & Windus.
The author is a science journalist who decides to travel the world to see what is happening to the earth's surface and what people are doing to find solutions.

Reading List for Students

Friends of the Earth <http://www.foe.org/>
Focused on the economic drivers that are encouraging environmental degradation.

Scorecard: The Pollution Information Site <http://scorecard.goodguide.com/>
Allows students to investigate pollution in the United States at a local level.

Student Science <https://student.societyforscience.org/article/how-people-have-been-shaping-earth>
Great blog article on how humans are changing the shape of the earth.

World Organization <http://www.world.org/>
Includes the top 1000 most useful environmental related web sites to help students research chemical reactions associated to their Planetary Boundary.

World Resources Institute <http://www.wri.org/>
Research website focused on climate, energy, food, forests, water, and cities and transport.

List of Materials for Classroom Use

Big History Project <https://school.bighistoryproject.com/>
Sign up for a free teacher account, it might just be the best thing you do today.

Neo/Sci Lab <https://www.fishersci.com/>
All of the labs for this unit were contained in the Neo/Sci Chemical Reactions Lab Kit. This kit can be easily ordered through Fisher Scientific or other retailers.

Welcome to the Anthropocene <http://www.anthropocene.info/>
This is the website to go to find the most up-to-date information on the topic.

Content Standards

Next Generation Science Standards

HS-PS1-2 Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

HS-PS1-4 Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

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.

HS-PS3-1 Create a computational model or simulation of a phenomenon, designed device, process, or system.

HS-PS3-2 Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.

HS-PS3-3 Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

HS-PS3-4 Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Connections to Engineering, Technology, and Applications of Science

- Modern civilization depends on major technological systems. (HS-ESS3-1),(HS-ESS3-3)
- Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-ESS3-2),(HS-ESS3-4)
- New technologies can have deep impacts on society and the environment, including some that were not anticipated. (HS-ESS3-3)
- Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ESS3-2)

Connections to Nature of Science

- Science is a result of human endeavors, imagination, and creativity. (HS-ESS3-3)
- Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. (HS-ESS3-2)
- Science knowledge indicates what can happen in natural systems—not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge. (HS-ESS3-2)
- Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues. (HS-ESS3-2)

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS3-1)

Systems and System Models

- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS-ESS3-6)

Stability and Change

- Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS3-3),(HS-ESS3-5)
- Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS3-4)