Cosmic chemistry with radioactive wrinkles

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Overview

Chemistry can be summarized in a few words as the study of matter and energy transformations. The rate of chemical and nuclear reactions are not limited by mankind's interpretations through the limitations of human senses and technological tools of measurement. As a humanity significant progress has been made, however there is so much more to understand and explore and connect between the atomic scale of chemistry and the astronomical scales of cosmology.

In light of the infinite possibilities, a foundational core structure for this introductory unit is prepared for 11th grade students with 55- minute classes. The unit may easily be adapted for middle school students. The journey begins with students choosing from a selection of unfamiliar vocabulary terms. The students will be able to:

1/ Define and explain the vocabulary concepts
2/ Individual or student pairs will research, explain and share their understanding of the assigned word with the learning community using images to visually support their research.
3/ Student cooperative groups will develop further questions on the keyword concepts based on the leveled Bloom's taxonomy questioning approach.
4/ Student expert groups will create a Powerpoint or Prezi presentation with researched responses to their inquiry questions to present to the community of learners.

Rationale

This unit is dedicated to my students who are transitioning from years of accepting that only one answer can be correct, and that an immediate answer can be "googled" to a learner that can peacefully navigate ambiguity in an era of information exuberance. The 21st Century educational rhetoric promotes the inquiry model of teaching and learning. However the challenge through this evokes anxiety amongst so many of my students. As my role shifts from imparter of knowledge to facilitator of life long personalized learning I find myself asking students questions as responses to their questions in an effort to guide them towards their own next growth milestone and subsequent answers… and then again further evolving questions: A continuous journey in which the *quality* of the questioning *is* the guide to solutions. This very process is disruptive to my students previously held beliefs and experiences. It requires skills to evaluate credible sources of information to make sound choices and evidence based evaluations amongst the limitless grandiloquence barking at us and saturating our senses.

We as a community are challenged to carve out time through our "busy ness" to pause, think and reflect. The very process of pausing and reflecting appears luxurious rather than necessary. To contemplate our questions along with our responses as we resolve immediate responses or long-term sustainable solutions to our problems as a local and global community. This unit is designed to build our muscle as learners, to trust our innate wisdom with individual student voices through collaborative choices.

In pedagogy both Piaget and Vygotsky contributed towards our current understanding of cognitive development in a child. However it was Vygotsky's theory that stressed the importance of cultural language on one's cognitive development. In agreement with Vygotsky, I will attempt to create connections through use of language and the understanding of fundamental concepts in chemistry and cosmology using vocabulary. In science each word had an entire concept with which it is associated. As an introductory session this unit would enable students to develop connections between chemistry and cosmology by understanding the concepts supporting the words.

The technology-supported student driven study provides a climate that allows for flexible and unique learning interests and the study of multiple levels of complexity. The environment fosters deepened and expanded understanding and establishes a platform to collaborate and contemplate nurturing enriched thinking and learning. According to Schon, 1983, learning is a dynamic process of "reflection-in-action" where action is used to extend thinking, and reflection is governed by the results of action.

In chemistry students know the Periodic Table as the alphabet of atomic structure. The curriculum predominantly focuses on chemical interactions; nuclear chemistry may be an optional addition. This unit may serve as an extension to the Nuclear Chemistry Unit or stand alone as a direct connection of elemental behavior operating under a variety of conditions in the landscape of the universe – as we know it. The goal is to spark student curiosity into the infinitesimal realm of the cosmos.

Objectives

This unit is intended for high school students in an urban setting. My students are diverse in how they engage with learning through narrative, concepts and mathematical ideas. Furthermore, my students are currently preoccupied with preparing for college admission. As they navigate and negotiate through the day, my students are embedded in a digital social cultural environment in which communications are rapid and real-time. The same approach is used to respond to questioning through rapid research using digital media. As such compromises are made in connecting deeper understanding of concepts associated with vocabulary and holistically contemplating the whole, or the larger context of the conceptual application.

This unit attempts to explore that active learning space through the use of structured development of student questioning, collaboration and contemplation.

At the end of this unit students will be able to:

- Analyze components, processes and systems in the cosmos
- Formulate questions and responses to their inquiry of the universe
- Create a presentation to share their explorations with the learning community

Strategies

The unit is designed as a student centered inquiry model project with chemistry students watching the NOVA produced documentary on our universe. Students are asked to create questions for all to consider as they venture through this unit as they watch the video. Following this lesson students are assigned vocabulary words to explore, they may choose the words or they may be assigned to student individual or pairs. Students will research these words to produce a PowerPoint using guided questions to construct their presentation.

The following lessons will be student lead presentation whereby students become subject matter experts until all the presentations are completed.

Thereafter students in groups will develop questions based on the leveled Blooms Taxonomy, and research and respond to these questions and share their interpretations with class presentations. Students can use the earlier vocabulary to create a collage of learning groups, connecting concepts and ideas.

This unit will use credible websites, articles and videos for students to gather historical, scientific and information about the universe through guided questioning structures. Students will migrate towards their own area of interest and investigation. The educator role is to drive the process amongst student individuals and groups towards evolving the questioning and research responses. The goal is for students to strengthen and deepen their practice through the autodidactic process.

Classroom Activities

Lesson 1

Introductory video of the cosmos
NOVA Space Exploration – "Our Universe" 2015 Documentary
https://www.youtube.com/watch?v=ZtaKWt26dNs

Students are asked to watch the video and create 3 essential questions in groups of 3 and write them down on post-it notes to paste and park on the "universe poster" to be used as anchors through the unit learning process for all students.

This will be used for guidance and inspiration for all students as they explore the universe.

Lesson 2

Select or be assigned a vocabulary word cut each box in the following table and assign (with underlying concept) to research and investigate to create a PowerPoint that would address at least the following guiding questions:

- What is it? What is it not? (compare)
- Why does it happen?
- How does it form? What conditions are necessary?
- When did it happen? How does the time measurement compare with human life years?
- Scales of measurement? Established historical timelines? Rate of reactions?
- Who contributed? Refuted? Originated? Terminated?
- Why would we as humanity be interested to know? What can we do knowing this?
- Explore similarities in understanding on earth systems and cosmological systems

galaxy elliptical/irregular/spiral	cosmic background radiation	decoherence	nebular theory
constellations	nuclear fusion	Doppler effect light/sound	jovian planet
brightness absolute/apparent	dark matter MACHOS/WIMPS	nucleosynthesis	terrestrial planet
parallax	dark energy	Life cycle of a star	theory of relativity
light year	redshift/blue shift anisotropy	Hertzsprung-Russell diagram	gravitational lensing
electromagnetic radiation	optical spectra luminosity	Big bang theory	$E=MC^2$
black holes/white holes	telescopes	Anthropic principle	String theory
worm holes	hydrostatic equilibrium	solar system	multiverse
geodesic	nuclear fission	quantum tunneling	singularity
neutrino	primordial soup	quasar	superposition
photon	satellites	quark	abiogenisis

Lesson 3 & 4

Students will share their researched PowerPoint Presentation vocabulary concept with the class.
(10 minutes per student/pair)

The peer audience is divided into groups (total of 6). Each group will be assigned a level of questioning to create based on Bloom's Taxonomy of questioning to further deepen their autodidactic practice. Each group produces 3 questions. After each presentation the questions are collated and handed to the presenter.

Bloom's Taxonomy Audience Groups:

1/ Remembering

2/ Understanding

3/ Applying

4/ Analyzing

5/ Evaluating

6/ Creating

Lesson 5 & 6

Each student group will select from one of the following project presentation expressions for a culminating activity to share as a mini-lesson to the class.
(15 minutes per student group)

- Students will use PowerPoint or Prezi with accompanying illustrations and sound to discuss the connections between cultural or conventional chemical concepts and the connections with cosmology
- Students will create an iMovie/ app to create a science fiction story based on the concept
- Students will compose and illustrate a book comparing a cultural interpretation concept with contemporary cosmology.

Annotated Bibliography/Resources

Bibliography (APA)

Teacher Resources

Rothstein, D., & Santana, L. (2011). *Make just one change: Teach students to ask their own questions*. Cambridge, Mass: Harvard Education Press.

> This is the key book that gave me the audacity to create this unit based on student driven questioning and responses.

Hannafin, M. J., & Land, S. M. (1997). The foundations and assumptions of technology-enhanced student-centered learning environments. *Instructional science*, *25*(3), 167-202.

> In this article the authors argue that prior to technological advancements student-centered learning environments were formidable due to logistical problems. However, technology-enhanced student learning environments provide interrelated learning themes that provide for complimentary activities to address unique learning interests and needs.

Johnson, D. W., & Johnson, R. (1999). Learning together and alone: Cooperative, competitive, and individualistic learning (5th Ed.). Boston: Allyn & Bacon.

> The authors in this article reinforce the interdependent learning value of collaborative groups and the roles that lead that lead towards accomplishing a common goal.

Wiggins, G. P., McTighe, J., Kiernan, L. J., Frost, F., & Association for Supervision and Curriculum Development. (1998). *Understanding by design*. Alexandria, Va: Association for Supervision and Curriculum Development.

> This book cites Bloom (1956) and his creation of the taxonomy and that there are different types of understandings. He argues that knowledge and skill do not automatically lead to understanding

Myers, R. T., Oldha, K. B., & Tocci, S.(2004). Chemistry. New York: Holt, Rinehalt and Winston.

> This is a high school chemistry textbook.

http://www.nap.edu/read/13165/chapter/9

The nap.edu website addresses practices, crosscutting concepts and core ideas for the K-12 science educator. It is a tool to look at grade bands and conceptual systems rooted in the physical sciences.

http://nasawavelength.org/resourcesearch?facetSort=1&educationalLevel=High+school&page=3

The NASA website has short clips and mini-lesson resources to assist students who may need additional support and assistance with video clips and resources.

http://cosmictimes.gsfc.nasa.gov/teachers/curriculum/lessons.html

NASA Lesson Plans and teacher resources to guide and support the needs of all students beyond the activities presented in this unit.

http://www.pbs.org/wgbh/nova/education/resources/subj_02_00.html

http://www.pbs.org/wgbh/nova/education/resources/subj_12_00.html

NOVA teachers guides for additional video resources

http://static.pdesas.org/content/documents/PA%20Core%20Standards%20for%20Reading%20in%20Science%20And%20Technical%20Subjects%20March%202014.pdf

A Pennsylvania State reference tool that addresses the academic standards for reading in science and technical subjects

https://21stcenturycompetencies.wikispaces.com/file/view/Blooms%20Taxonomy%20Flip%20Chart%20for%20Student%20Use.pdf/439574600/Blooms%20Taxonomy%20Flip%20Chart%20for%20Student%20Use.pdf

A website to access to a Bloom’s Taxonomy Questioning tool template for student use.

Student Resources

Jackson, T. (2012). The elements: An illustrated history of the Periodic table. New York: Shelter Harbor Press.

This book gives multiple views at the understanding of the periodic table and lends to interesting questioning, folklore and discussions

http://imagine.gsfc.nasa.gov/resources/

http://www.physicsoftheuniverse.com/glossary.html

These websites are introductory vocabulary and concept starting points for students

http://www.hippocampus.org/HippoCampus/Chemistry;jsessionid=A10D345F132F27C1A9DF8A46698E4937

http://open.umn.edu/opentextbooks/BookDetail.aspx?bookId=155

Although most of my students have a preference for audiovisual material materials to access learning, these open source textbooks are options to deepen inquiry.

http://www.space.com/science-astronomy/4?type=infographic

Info graphics appear to provide context and data for further discussion, so it is a useful accompaniment

https://www.sciencedaily.com/news/space_time/nasa/
http://www.space.com/science-astronomy/5

Current space news introductory websites

http://www.elementsdatabase.com/

Any chemistry unit would be incomplete without a reference periodic table on hand.

Appendix/Content Standards

Pennsylvania Common Core State Standards (http://www.pdesas.org/Standard/PACore)

Reading Informational Text Students read, understand, and respond to informational text – with emphasis on comprehension, making connections among ideas and between texts with focus on textual evidence.
CC.3.5.11-12.G. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
CC.3.5.11-12.H. Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
CC.3.5.11-12.I. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Next Generation Science Standards (http://www.nextgenscience.org/)

CC.3.5.9-10.A. Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.

CC.3.6.9-10.E. Use technology, including the Internet, to produce, publish, and update individual or shared writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.

CC.3.6.9-10.F. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

Content Core Standards

PS3.A: Definitions of Energy
Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HS-PS3-1), (HS-PS3-2)

At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS-PS3-2) (HS-PS3-3)
These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS-PS3-2)

PS3.B: Conservation of Energy and Energy Transfer

Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1)
Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1), (HS-PS3-4)
Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1)
The availability of energy limits what can occur in any system. (HS-PS3-1)
Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (HS-PS3-4)

PS3.C: Relationship Between Energy and Forces

When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3-5)

PS3.D: Energy in Chemical Processes

Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. (HS-PS3-3), (HS-PS3-4)