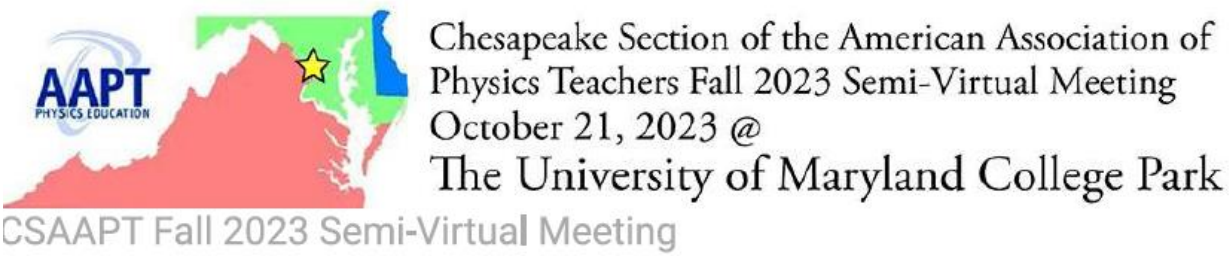

Chesapeake Section of the American Association of Physics Teachers (CSAAPT) is a regional organization consisting of Delaware, the DC area, Virginia and Maryland, and are part of the national AAPT. The goal is "…the advancement of the teaching of physics, the professional advancement of the teachers of physics at all levels, and the furtherance of the appreciation of the role of physics in our culture."

Science as Final form Ideas vs Science as Practice —Teaching High School Physics in Space Weather Studies

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Abstract
Science instruction is often criticized for focusing on the memorization of discrete concepts, facts and laws. The focus students perceive science as a set of *final form* ideas suggesting little change over time (Duschl, 1990). There is often a focus on one "right answer" rather than an exploration of ideas that includes incorrect or partially correct explanations (NRC, 2015). However, research and reform efforts identify evidence as an essential component of science classroom instruction to actively engage students in science practices. In science-as-practice, students develop and demonstrate knowledge as they build explanations of phenomena (Berland, Schwarz, Krist, Kenyon, Lo & Reiser, 2016; Krajcik, Codere, Dahsah, Bayer & Mun, 2014, Lehrer & Schauble, 2006). Scientific evidence fosters the work of science learners from individually learning final form and isolated facts to actively participating in knowledge construction practices because of the emphasis on evidence in existing policy and research. This paper aims to explore how conceptual cognitions result from students making sense of "scientific evidence" as phenomena is explained.
Keywords: Global Positioning System (GPS), Total electron Content (TEC)

Background
Last year's presentation "STEAM---Teaching Space Weather Studies" demonstrated a hybrid visual-kinesthetic learning style in showcasing presence of subatomic particles and their impact on Low Earth Orbit satellite operations that might cause disruptions to what people employ on Earth, including cable communications, Internet, GPS. Students matched narrations to ordered visuals depicting different phases of particle propagation leading to failed satellite operations and disruptive Earth receptions. What last year's visuals lacked were satellite data collected for which students could correlate to operational anomalies or end-use disruptions. The "scientific evidence" for disruptions to Earth communications, navigation, and Internet services was missing.

Introduction
The Geostationary Operational Environmental Satellites (GOES) are a series of key satellites National Oceanic and Atmospheric Administration has used to monitor weather and space weather since 1975. These satellites carried multiple series of space-weather instruments for measuring particles, the magnetic field, solar irradiance, and solar image monitors. GOES electron measurements have been made since the first GOES satellite. The electron flux measured by the GOES satellites indicates the intensity of the outer electron radiation belt at geostationary orbit. Measurements are made in two integral flux channels, one channel measuring all electrons with energies greater

than 0.8 million electron Volts (MeV) and one channel measuring all electrons with energies greater than 2 MeV. Electron Event ALERTS are issued when the >2 MeV electron flux exceeds 1000 particles/(cm^2 s sr). High fluxes of energetic electrons are associated with a type of spacecraft charging referred to as deep-dielectric charging. Deep-dielectric charging occurs when energetic electrons penetrate into spacecraft components and result in a buildup of charge within the material. When the accumulated charge becomes sufficiently high, anomalous behavior in spacecraft systems and can result is temporary or permanent loss of functionality can occur. The North American Total Electron Content (NA-TEC) product is designed for single and dual frequency GPS applications. It provides a near real-time assessment of the Total Electron Content (TEC) which is often used as a proxy for GPS position error. The TEC maps can be used to estimate the GPS signal delay due to the ionospheric electron content between a receiver and a GPS satellite.

Unfortunately, students often interpret "data as factual rather than [as] constructed and open to interpretation" (Sandoval & Çam, 2011). Instead of considering data as constructed, students tend to objectify evidence as self-evident (Manz, 2016). Scientists work to *make sense* of nature—to develop understandings of how and why nature works in the ways that it does (Russ, Coffey, Hammer, & Hutchison, 2009). This sensemaking requires three "transformations" of data or the information observed in nature (Duschl, 2000):

> Transformation 1 --- to evaluate what raw data becomes the selected data or evidence.
> Transformation 2 --- to evaluate how the evidence can be manipulated to locate patterns.
> Transformation 3 --- to evaluate how the patterns fit, or not, scientific theories or explanations.

Situating science ideas within real world contexts "plays a powerful role in facilitating student learning through both motivational and cognitive means" (Rivet & Krajcik, 2008). Consequently, scientific evidence used in k-12 classrooms should focus on information that is phenomena-based, consisting of empirical data about phenomena in the natural world. Even if a phenomenon cannot be directly observed in a science classroom, learning activities can still be designed to provide more direct links to phenomena.

Purpose

Per this year's presentation "Science as Final form Ideas vs Science as Practice —Teaching High School Physics in Space Weather Studies**",** a class activity is provided to introduce students to reading one of NOAA's products and how such readings are applied in operations management.

Method and Results (in progress)