Curriculum Units by Fellows of the National Initiative
2021 Volume IV: The Sun and Us

Stardust Students-Our Class Cosmos of the Stars

Curriculum Unit 21.04.06, published September 2021
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The astronomer Carl Sagan said, "The cosmos is within us; we are made of star stuff; we are a way for the universe to know itself." This belief that the universe is within us, and that we are a part of it and its future, is an ideal that we can give our students. However, this can only happen if we take the time to invest in our students' whole being as students, people and future citizens. Teaching the whole child and allowing students to grow their love of learning through sciences and arts is not only important to their growth as students, but as people. Teachers today have the future of the world in their classrooms and have an obligation to equip them fully.

The Marginalization of Science and Social Studies in the Classroom

As science, technology, engineering and social studies are further marginalized within classrooms in inner-city school districts in the United States, we are taking the gift of passion and connectedness away from our students and diminishing the full scope of what their education and learning can be. According to the Center for Educational Policy, 28% of school districts in the U.S. have reduced science time in the classroom.[1]

> "This "narrowing of the curriculum" is indicative of urban and low-performing schools and is mainly a consequence of intense pressure to boost test scores (Crocco & Castigan, 2007; Spillane & Callahan, 2000; Upadhyay, 2009); unfortunately, in many states, science test scores are not part of the accountability equation."[2]

The emphasis that is placed on raising standardized testing scores, comes from the widening gaps that are a result of failing to make equity, accountability and instructional level the priorities and primary focuses within our classrooms. Many districts spend thousands of dollars of budget spending per year on Curriculum Programs, many of which take the entire day to teach. These programs, and the time constraints that come with them, are then used as the justification for marginalizing social studies and science instructional time in our classrooms. This is not to say that these gaps within literacy and mathematics are not important, they are, but literacy in the sciences and social studies matter greatly as well. As Professor of Education Dr. Bettina Love was writing about renowned educator and researcher Dr. Gholdy Muhammed in the introduction of her book, *Cultivating Genius*, she stated the view of literacy for Dr. Muhammed and how we should all be viewing literacy education in the United States:

> "…her ability to articulate why literacy is important beyond the surface of learning how to read and write, as a necessary tool for justice, equity, and a world where the humanity and dignity of those pushed to the edges of society are front and center."[3]

We should be viewing literacy and mathematics as necessary; this can be addressed only through best practices teaching in literacy and mathematics through direct instruction, and not through cutting out science and social studies. There should be time for all subjects to be taught with equity within the school day. This way, we will allow students to know themselves and cultivate their passions for learning. In addition, schools that prioritize science instruction and accountability within their testing, do not see a decrease within areas of literacy and mathematics as a result of making space for that instruction.[4] As districts are trained in STEM (Science, Technology, Engineering and Math) practices, they can begin to implement it within the classrooms and see the major benefits to our students that it brings. We cannot teach students to know about themselves, or about the universe they are a part of, by removing science and social studies from the classrooms; we need to emphasize these content areas immediately.

STEM in the Classroom

To address the need stated above, we can begin to appropriately address the topics that students encounter in the science classroom to implement STEM learning. One topic that students in K–5 classrooms are presented with year after year (if the school has made science a part of the school day) is the Solar System. This topic is incredibly vast in what we can teach students, but alas the topic is typically constrained to a textbook lesson about the order and sizes of the planets, the phases of the Moon, and typically a catchy video to round out the subject. There is, however, so much more we can share with our students about the Solar System, and we can share it in a much more engaging and meaningful way through STEM. Teaching students through STEM learning is vitally important for the future of our planet. In an article by the American Educational Research Association on the effect sizes of science instruction (effect sizes meaning the research based data averages on the effectiveness of a particular teaching strategy or teaching method), it was found that the overall mean effect size of science instruction on achievement was 0.486, and therefore, above the effective mark of 0.4.[5] Not only is science instruction effective in the learning environment, but it can help our students prepare for the future. In 2017, the U.S. Department of Commerce reported that the number of STEM related jobs has increased by 24.4% over the previous ten years.[6] As this was in 2017, school districts that have not begun implementing STEM as a normal part of the school day and curriculum, have fallen drastically behind in the journey to provide students adequate education to prepare them for the world. This has put their students behind in the learning journey. This issue must be addressed, so that this does not continue to happen to our students. STEM can be used as the vehicle to address the science content in a unit-based and interactive way.

Introduction & Demographics

I have always enjoyed teaching about the Solar System to my students and about how large the Universe really is. The vast nature of space, and all that there is to be learned by it, seems to be highly interesting to them. The demographic of students that I teach in fourth grade for Richmond Public Schools currently is 75% African American, 15% Latinx, 9% Caucasian, and 1% Asian and indigenous students.[7] Due to these demographics, it is of the utmost importance that every lesson or curriculum plan I write is done so with cultural responsiveness in mind. I plan to use STEM to address the topic of the Solar System, and to address a seldomly explored topic more specifically within the elementary classroom: *the stars*. Many students are not aware that the Sun is a star, or what makes up a star, or what its characteristics are. We will discuss this as a class, as well as extensions to the unit on cultural views of stars, and astronomers of varying ethnic backgrounds, and their contributions to science.

Overview

I am creating a unit entitled: *Stardust Students*: Our Class Cosmos of the Stars. This is a four-week unit, in which I will begin the unit by giving the students an overview of the universe, galaxy and solar system: *planets, moons, Sun and stars*. The next component for students will be learning about the Sun as a star, including the concept of solar energy. Students will use this time to learn about the different properties of the Sun, its existence as a star, and how it relates to the topic of stars in general. The unit will then then explore the formation and life of a star. Once this context is in place, the unit will be at the point of its main focus, which is the classification of stars. Stars and their characteristic make-up the bulk of the Curriculum Unit, and this is the topic students will research for their culminating project.

The main section of the Unit will be learning about the life and characteristics of a star. Students will learn about how stars are categorized by *color, temperature, mass, luminosity, apparent brightness, location, distance and sounds*. Students will catalog this information about stars into an interactive journal and into a concept map about stars. This knowledge of the properties of a star, will culminate into a *Class Cosmos*, where students will create their own *star*, by selecting different characteristics of their star and creating a model. Students will complete a display board that shows the characteristics of their star. These stars will be put together into a whole class display and presentation. At the end of the Unit, we will purchase a star through a naming directory and name it after our class! This unit will give my students greater understanding of scientific processes and thinking and the solar system including the sun and stars. This will also give my students an opportunity to engage in STEM activities as a class.

Students will learn about the life of a star, and the changes that it goes through over its lifetime. We will discuss the census of stars, and their relation to the Earth and the Sun, as well as discuss stars that are able to be seen with the human eye and how atypical they are in terms of distance.[8] Our discussion will include the birth and formation of a star. We will discuss the steps of this star formation and how it begins with a core, gas and dust.[9] For students to truly understand stars, their life, components and characteristics, they must understand what they see with stars, as opposed to what stars really look like up close. To address this, students will also explore the concept of *luminosity* and how it compares to *apparent brightness* of stars.[10] We will then discuss how stars are classified in terms of brightness, color and temperature. This will be an integral part to the final curriculum unit project that students will take part in, as students will be replicating this identification in a chart for their own project. We will also discuss the distance from earth a star is, and the concept of light years.[11] Some additional stellar properties that we will discuss are the same as those we will discuss about the Sun in the introduction to the unit. These include mass, radius, surface temperature, core temperature, luminosity, average density and age.[12] We will also discuss the size, shape and metallicity of stars in terms of their evolution over time.[13] Additionally, I will also present my students with the sounds that stars can make. My hope is that this will inspire them to engage more with the learning process about stars.

Unit Content, Structure and Components

The Universe, Our Galaxy and Our Solar System

The Universe and Our Galaxy

The diameter of the universe "…is about 93 billion light years in diameter".[14] This means that if we think of the universe as a sphere like a soccer ball, and we calculated the distance across the whole universe would be about 900,000,000,000,000,000,000,000 (900 sextillion) miles across.[15] That would be like taking the Earth and lining it up 100,000,000,000,000,000,000,000 times. These numbers are almost unfathomable to our minds. Consider that our solar system is one of more than 5,000 known solar systems just in the Milky Way galaxy alone[16] , this means that the Milky Way contains other planets that many people do not know much about. Just as there are many more solar systems in our Galaxy, the universe is made up of roughly 100 to 200 billion other galaxies besides ours.[17] This means that these other galaxies can in turn have planets and solar systems as well. There are different types of galaxies based on their shapes: spirals, ellipticals, irregulars, interacting and active Galaxies.[18] According to *Astronomy Made Simple by Dr. Marvel*, "The Milky Way is an average spiral galaxy with a diameter of about 100,000 light years".[19]

Our Solar System

Our solar system consists of the planets Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune, and Pluto, which has been categorized as a dwarf planet. "Mercury is the planet that is closest to the sun; as a result it is often blocked from our view by the light of the sun itself" (Marvel, 72).[20] This terrestrial planet has a diameter of 3,032 miles and is 35,983,605 miles from the Sun.[21] Also due to its closeness to the Sun, Mercury has very different temperatures on either side of it.[22] The side of Mercury that faces the Sun can reach 800 degrees Fahrenheit and the other side of Mercury can reach negative 300 degrees Fahrenheit.[23] Mercury is considered to have high density, a powerful magnetic field and it is suspected that it has a core made of metal such as iron.[24] Venus, the next planet, has a diameter of 7,521 miles and is 67,230,000 miles from the Sun.[25] Venus has many clouds around it and has a dense atmosphere.[26] Venus also gets extremely hot, at 900 degrees Fahrenheit.[27] Venus has properties that are similar to earth such as mass and size, but due to the fact that Venus has an atmosphere of Carbon Dioxide that is so dense, the greenhouse effect on Venus has taken over the entire planet.[28] Venus has been found to have a rocky and semi-volcanic surface.

Earth, has a radius of 3,959 miles and is 92,960,000 miles from the sun.[29] "Earth is composed of large areas of land called continents and vast oceans of liquid that cover about 70% of the planet" (Marvel, 78).[30] Plate tectonics (the shifting of the tectonic plates on earth's surface), erosion (the weathering and wearing away of Earth's surface), and the hydrologic cycle (the way that water cycles and travels through and around the earth) are the causes of constant changes to our home planet.[31] Our moon is the largest of those among the terrestrial planets and is about 230,000 miles away from us.[32] Mars is the next planet from the Sun, and has been the target of the largest portion of space exploration for life on other planets.[33] Mars has a diameter of 4,222 miles and is 141,000,000 miles from the sun.[34] Similar to Venus, the atmosphere of Mars is made up of carbon dioxide, however, the atmosphere is too thin to trap heat by the greenhouse.[35] According to *Astronomy made Simple* by Kevin Marvel, "Mars has volcanoes, craters, canyons and polar ice caps".[36] Mars is also a cold planet, as its temperatures are usually at freezing temperatures.[37]

The next planet in our solar system, Jupiter, is our largest planet. Jupiter is so large that it would be possible to fit about 1000 planets the size of earth inside of it.[38] The atmosphere of Jupiter has red, brown, orange and white colors.[39] Jupiter is also identified by a large red spot the *Great Red Spot* which is the result of a disruption in Jupiter's atmosphere and is essentially a gigantic hurricane. Jupiter has a diameter of 88,850 miles and is 483,600,000 miles from the Sun.[40] Jupiter is also a fast planet, as it rotates once every ten hours, and therefore has very strong winds of over 100 miles per hour.[41] Jupiter is very hot closer to the core, and below freezing above, and has a very high amount of pressure.[42] Many moons (*more than seventy!*) orbit Jupiter, the largest being Callisto, Europa, Ganymede and Io.[43] Saturn is the next planet from our sun, a diameter of 74,900 miles and is 888,200,000 miles from the Sun; Saturn is also the second largest planet in our solar system.[44] The rings of Saturn are made of chunks of ice and rock, and they rotate between 30,000 and 44,000 miles per hour.[45] Saturn is cold planet as it has an atmosphere that is made of helium and hydrogen and is farther from the sun; water, has a higher density than Saturn. Saturn too has many moons; the largest a large moon is called Titan and is the only moon that has an atmosphere of its own.[46] Uranus and Neptune, are far out in our solar system. Uranus has a diameter of 31,760 miles and is 1,784,000,000 miles from the Sun, whereas Neptune has a diameter of 30,780 miles and is 2,799,000,000 miles away from the Sun.[47] Uranus is tipped almost completely on its side, and one half of the planet will be dark and the other light for about half of a year.[48] Neptune is a cold planet and has a temperature of about -350 degrees Fahrenheit.[49] This information on the planets can be accessed in a reference called: *Astronomy Made Simple* by Kevin B. Marvel. As the main topic of this unit is stars, to give students a context, we will begin with the Sun, our closest star.

The Sun: Our Star

The Sun is the star closest to us and is the center of our Solar System. Instruments on the Solar Dynamics Observatory allow us to image and view the Sun in many wavelengths.[50] Other space missions, like the Solar and Heliospheric Observatory (SoHO) have *coronagraphs* that can produce a virtual eclipse of the Sun through technology and image its outermost layers that are generally hidden by the glare of sunlight.[51] Astronomers use these very powerful telescopes to try to observe the sun, stars and other stellar objects.[52]

Prior to our technical age, many cultures that have studied and worshipped the Sun for hundreds of years, and many of these cultures set their calendars by the Sun as well. Cultures such as ancient Egypt worshipped the Sun God Ra, and other indigenous cultures represented as Father Sun and Mother Earth.[53] In addition to these cultures, we will learn about the Sun mythology of Hinduism with the Sun God Surya,[54] as well as the mythology of the god Anansi in Africa.[55] Once we discuss this history of the Sun as well as its place in our solar system, we will transition into the basics of its composition.

The diameter of the Sun is roughly 864,938 miles, and therefore the circumference is roughly 2,713,406 miles.[56] This is quite astounding when we consider the size and diameter of the earth and the other planets. “You could line up 109 earths across the face of the Sun”.[57] The Sun is not only large in comparison to our earth and other planets but is composed of things that we should discuss as we educate about its solar power and materials. The Sun is made of mostly hydrogen.[58] This is important to explaining the fact that the sun is a low mass star, but the mass of the sun is over 700 times the mass of the earth and all the planets put together.[59] The Sun is composed of varying layers and elements. According to NASA, the Sun can be divided into about seven different layers and/or zones. These layers and zones are made up into the inner layers which are: the core, the radiative zone and the convection zone;[60] and the outer layers which are: photosphere, chromosphere, transition region and the corona.[61] The core of the Sun is the center and inner-most region, which, like the rest of the Sun is made of hydrogen, helium and small amounts of other materials.[62] This is where energy is produced through nuclear fusion which change the hydrogen to helium.[63] The radiative zone is where energy from the core is transferred through radiation.[64] This region of the Sun is about two to seven million Fahrenheit depending on where you are in this zone, the temperature drops and pressure drops too.[65] Above the radiative zone is the convection zone where heat is transported by the movement of gas ¾ gas closest to the radiative zone gets heated and rises and as it rises it gives off heat and cools down, the cooler gas then sinks back down and gets heated again and so on.[66] This convection brings heat to the photosphere, from where it leaves the Sun.[67] As for the outer layers of the Sun, the photosphere (literally “sphere of light”) emits light we can see, and is the layer which is the “surface of the Sun” and on which we can view phenomena such as sunspots.[68] The next layer, the chromosphere, is the layer in which the Sun emits a red light.[69] The transition region connects the chromosphere to the corona and is a layer where temperature increases dramatically. The corona, is the outer atmosphere of the sun.[70] Sun’s light can also be studies through spectroscopy, which means that the different wavelengths of light are separated out and studied by themselves, thus is how we determine what the Sun is composed of.[71]

We can see with our eyes that the Sun is incredibly bright. While the Sun does emit a lot of energy, the brightness that we see from the Sun can be attributed to how close the Sun is to the earth. According to astronomical studies, there are 149,597,870,700 meters between the earth and the Sun.[72] While these numbers are high, we know that the sun is not the only star of its kind. We know that the Sun is not the largest star in our universe.[73] The Sun is considered mid-sized in comparison to most other stars in our Galaxy.[74] According to NASA, “There are stars that are 100 times bigger in diameter than our star”.[75] This is difficult to fathom, as our Sun seems so large to us. For example, the star UY Scuti is also in our Galaxy, and has been found to be 1,700 times larger than the Sun.[76] The Sun powers our planet, but how do we know just how much power we are receiving from the Sun as a whole? We know that the Sun is producing 380 quintillion (380,000,000,000,000,000,000) megawatts in measures of energy.[77] In thinking about our modern times and energy, trying to fathom the amount of energy the Sun emits can be difficult. We can however, put this into simpler terms now. “…the Sun emits enough energy every second to provide for all the world’s current energy needs for 5,000 years” (Golub, Pasachoff, 12).[78] We have not mastered how to collect and utilize all the power from the Sun that we can. As many people in our world convert to solar power for the planet, this could be researched. Knowing how much power the Sun emits also allows us to understand its temperature.

The Sun is about 10,000 degrees Fahrenheit on its surface.[79]

The Sun is not only a mid-sized star, but it is also a middle-aged star.[80] The Sun is about 4.6 billion years old at middle age,[81] and is a yellow dwarf that will eventually become a red giant, and will end its life as a white dwarf.[82] The Sun's age is important, when we analyze its energy, as well as the length of time that it can sustain the earth. Our Sun does not have any other large stars around it.[83] According to NASA, "…solar systems can have more than one Sun; In fact, that is often the case".[84] Our Sun is unique because it is the only one, we have.[85] As the Sun is a star, all of these aspects of our Sun are vital to understanding stars themselves and their characteristics, formation and phases.

The Life and Characteristics of a Star

Star Formation

Figure 1: An image of the birth of the star by the Hubble Telescope. Photo credit: nasa.gov

Once students understand the sun as a star, they can begin to understand more about stars are and how they are formed. The images taken by NASA and the Hubble Telescope show amazing views of a stellar nursery where stars are forming.[86] We can also view images of the Orion Nebula to show the new stars inside of the clouds in space.[87] Stars form and are born in very large, dense, cold parts of clouds in space called nebulae.[88] Stars are formed when these clouds of gas and dust particles or *nebulae*, condense under gravity.[89] The temperature in these parts of the nebula where star formation begins is about 10 Kelvin.[90] White pressure impedes contraction, gravity dominates, and gravitational contraction causes clumps within these clouds to contract further, the contraction causes the gas to heat up more and more.[91] This condensed gas in this section of the cloud that has heated up is also called a protostar, will reach higher and higher temperatures.[92] Further contraction will heat up the core of the protostars enough to begin nuclear reactions, and the protostar is now a star.[93] Stars only form under these specific conditions. Planets form from the excess gas around the forming star. According to *The Lives of Stars by Ken Croswell,* although the protostar is losing heat into space, "as gravity squeezes the star, the star keeps getting smaller; so, gravity heats the star and temperature rises more".[94] Croswell explains, "So, gravity starts a star's heat; Nuclear reactions keep the star hot; and heat and photons hold the star up against the gravity that gave it birth".[95] This balance of heating, cooling and gravity, is a part of a star's life cycle.

The longevity of a star's life span is determined by mass, which determines how much energy it has to produce to counteract gravity, which dictates the rate at which hydrogen is consumed and hence determine how long the star will live.[96] Lower mass stars will have a longer span than medium-mass or high-mass stars.[97] The lower the mass, the lower the luminosity; the higher the mass, the greater its luminosity.[98] Our sun is considered a low-mass star, which is why it has burned so long for us and is about middle aged, it is about 5 billion years old.[99] Stars fuse hydrogen in their cores.[100] According to Dr. Sarbani Basu of Yale University Astronomy, "The star essentially begins as hydrogen and helium as they are the most abundant elements in the Universe, and the nuclear reactions start hydrogen is being converted to helium because that occurs at comparatively low temperatures".[101] This process will continue at different rates depending on how much mass the star has.[102]

Eventually, all stars will run out of hydrogen to burn, and will go through the process of phasing out.[103] The core will have no hydrogen left, and is basically helium which requires much higher temperatures to fuse into carbon.[104] Since no energy is being produced, the core stars collapsing, heating up a layer of gas around the core which starts hydrogen fusion and the outer parts of the star expands.[105] The star will turn into a red giant.[106] Once the core reaches high enough temperatures to start helium fusion, energy will be released by fusing helium to form carbon and oxygen.[107] This continues until helium is exhausted, the core will start contracting again, the outer parts will expand again.[108] For a star like the Sun, this is the end of life ¾ the Sun cannot fuse carbon.[109] The core will become a white dwarf, as the outer layers shed. [110] Stars that are much heavier than the Sun will go though many more fusion processes and end their lives as supernovae and release the elements formed by fusion.[111] These elements are then recycled to form new stars and planets.[112] This is how the Earth got the different elements that we see.[113]

Star Classification

To understand the longevity of a star's life cycle, it is important that we be able to classify it. We can achieve this by using the spectral classes on the Hertzsprung Russell Diagram (a plot of stars' luminosity against its temperature) into the categories from hottest (highest mass, shortest life) to coolest (lowest mass, longest life) span based on their spectral classification type: *O, B, A, F, G, K, M*.[114] Originally, the stars were classed by just using alphabetical order.[115] These letters came as astronomers were able to study the stars more closely and were able to note details and important information about them, which then led to the narrowing of these specific letters shown.[116] We know now that the temperature scale runs hottest to coolest from O to M.[117]

On the HR diagram, stars can be charted by multiple categories, these categories include Color, Temperature *since color is related to temperature.* Stars are classified by Spectral type as stated above, that gives an idea of their temperature and luminosity.[118] Each of these properties of a star, help astronomers to determine the longevity of its cycle span, and how the star will behave over time.[119] These stars are also charted and classed, based on how large they are: super giants, giants, main-sequence stars and white dwarfs.[120] In addition, there are different types of stars in different age stages we will learn about such as: dwarfs and red giants.[121] During this curriculum unit, students will engage in stem learning, by creating a concept of their own star and charting it where it would go on the Hertzsprung-Russel diagram if it were to become a real star. We will keep a classroom map of these charted stars during our planning process.

Star Color and Temperature

Figure 2: The Colors of the Stars; Photo credit: nasa.gov

Star Colors are listed and generally span from shades of red, orange, yellow, white and blue. It is in this order that the stars actually move from coolest to hottest as well; cooler stars being red and orange K and M types, while the O and B type stars that are blue are the hottest.[122] Therefore, there is a clear indication that temperature and color in terms of stars, are related and we can determine the temperature by its color.[123] The core of a star has a much higher temperature than its surface layer.[124] We typically see as only small white lights in the sky when we look at the stars, when in reality, these small dots of what look like white light are actually a variety of colors that our human eye can't see from far away.

It is also possible to measure the temperature of a star, through the colors of the rainbow. [125] This is accomplished through a spectrum, which is the rainbow of all the light that a star gives.[126] This is organized in a specific way. According to the *Lives of Stars* by Croswell, "…they are organized by order of wavelength: purple light has the shortest wavelength, then blue light, then green, then yellow, then orange and finally red, which has the longest…”.[127] These colors, allow astronomers to determine the star’s temperature.[128] These wavelengths of spectrum color classification, measured and charted. These spectra of stars are recorded with the star classification types: *O, B, A, F, G, K, M*.[129]

Star Mass

Mass matters when classifying stars, as it generally determines the other characteristics of the star, and points to the longevity the star will have.[130] A star mass is how much material the star has within it.[131] It is not an easy thing to determine the mass of a stellar object, but it is possible.[132] Many stars are binary stars two stars that orbit each other.[133] “About half of all stars are binary stars.” Within these binary stars, the star with the greater mass, can give mass to the star with less mass.[134] Stars also have a range of mass. “Stellar masses range from about 1/12 to more than 100 times the mass of the sun”.[135] Stars that have more mass than the Sun do exist, just as stars that have less mass than the Sun exist.[136] Stars that have a very small amount of mass, compared to the Sun, are considered brown dwarfs.[137] Brown dwarfs are stars which so low a mass that they do not reach temperatures high enough for hydrogen fusion to take place. There is a relationship between luminosity and mass as well, as it is the case that high mass stars are also very bright.[138]

Luminosity vs Apparent Brightness

The categories of *Luminosity and Apparent Brightness* are charted on the Hertzsprung-Russell Diagram that was also referenced above.[139] Studies have shown that there are two type A stars, one type F star, seven type G stars, seventeen type K stars, ninety-four type M stars, eight white dwarfs, and thirty-brown dwarf stars that are in the neighborhood of our Sun.[140] There are many more stars that can be seen with the naked eye, but they are farther away.[141] According to *OpenStax Astronomy*, “Luminosity is the rate at which a star or other object emits electromagnetic energy into space; the total power output of an object”.[142] This means that luminosity is how bright the star actually is.[143] Apparent Brightness on the other hand, is how bright the star appears to be.[144] Just as a car’s headlight appears bright when it is close, but dim that is far away, a star of a given luminosity will appear brighter if it is closer to us, but dimmer if it is far away. Many of the stars around us that are closest are actually low in luminosity.[145] Some of these stars have low temperatures, and not as bright, therefore there may be more we have not seen yet that are close to Earth.[146] That is to say, that very few stars can actually be seen with the human eye without a telescope unless they have the right distance and/or luminosity.[147] Again, the luminosity of a star, is not dependent on how close the star is, but by energy it emits.[148] Both distance from us and a star’s luminosity explain why some stars appear most illuminated to us.[149] According to luminosity data, “The most luminous of the bright stars listed emit more than 50,000 times more energy than the sun”.[150]

Location, Distance and Census of Stars

In addition to thinking about the life cycle of stars and their characteristics, it is important to consider how we see the stars and chart them. Technology has advanced so much that we know have ways of charting new star births and charting this process for our solar system. Scientists chart stars in a census, and use of measurements taken when the Earth is in different parts of its orbit to determine how far away stars are since their distance is partially related to in which direction they appear to be when.[151] The unit used to measure how distances to stars is the “lightyear”, which is the distance travelled by light in one year.[152] According to

OpenStax Astronomy, "The closest star to us, is more than 4 light years away".[153] This, of course, is a star other than our Sun. Stars can appear to shift directions as astronomers observe them in relation to the Sun.[154] This is called parallax; which is what makes a star look like it has shifted directions in relation to stars that are very distance because the Earth is in a different part of its orbit.[155] As we use the Hertzsprung-Russell diagram, and determine the spectral classes of stars, we can also use the topic of luminosity discussed above, to determine the closeness of stars to us and to our Sun.[156] This luminosity as discussed above, is a result of the energy produced inside the star due to nuclear fusion and has no direct correlation of luminosity with distance ¾ some nearby stars are very luminous, as are some stars that are very far away. For example, Vega, Sirius, Altair, Alpha Centauri, Fomalhaut and Procyon are the only extremely bright stars that are close in proximity to earth, although there are more of these visible stars, we can see just as brightly.[157] This information about luminosity and distance can help us further classify stars and understand what we are seeing or not seeing in the night sky around us.

Star Sounds

There are some things that we will learn in life, that almost never become fathomable; things that are so hard to believe, even with evidence. An example of one of these things is the fact that stars make sounds! In fact, we can *listen* to the sounds that stars make, and use this as a classification tool.[158] The actual term for listening to and analyzing star sounds is Asteroseismology, i.e., the seismic study of stars.[159] Just as geophysicists use seismic waves on Earth to study what is happening inside the Earth and earthquakes, astronomers use seismic data of the Sun and other stars to study what is going on side those objects. These star sounds give astronomers a great deal of information such as: size, and mass, and can also be used to monitor internal changes in the stars.[160] This information is yet another amazing way we can study the stars around us.

Why are Stars important?

There are many reasons why learning about the stars is important. One, is the importance of being able to chart the age of the Universe.[161] The stars can be a direct indicator of the age of our galaxy and our universe as a whole.[162] The age of our sun and earth is one example. Another important reason for this study of the stars is how we continue to harness energy from our own sun.[163] The possibility of being able to harness energy from other stars as there are stars that are brighter and more powerful than the sun would be fascinating and groundbreaking to study if it became possible.[164] As solar energy is becoming more and more of a solution people are looking to, it would change things completely if there was more energy to be harnessed from other stars in space.[165] In addition to more star energy around us, there is also stardust within us.[166] There is scientific fact within how connected we are to our universe and its elements.[167] This means that we are directly connected to the history of the universe and stars around us, and it is literally a part of our DNA.[168]

Culminating Unit Project

This unit and the tasks associated with it will take place gradually over the course of the first marking period *or nine weeks*, of the school year. Students will learn about the introductory information on the universe, galaxy and solar system as context, as well as the stars and will complete interactive notes and stations about these aspects of space. Once this context has been set, and students begin to learn about the Stars themselves, students will create a *Timeline of a Star* in the class activities. This activity will be ongoing as students will complete one piece of the timeline per day as the warm-up, as we being to learn about the characteristics of a star. Students will use the NASA Timeline resource for stars to help with this timeline as part of our daily anticipatory set. For the main part of each lesson after about star classification, students will take interactive notes about a new characteristic of a star, complete stations based on this characteristic, and will determine in their graphic organizer how this will apply to the star they are creating. Students will use the same graphic organizer and notebook for this each day and will name the star they are creating on the graphic organizer. Once students have a base of knowledge about stellar characteristics, they will begin their final project, by constructing a star model using plastic orbs, colored bulbs, circuits and cardboard provided by the teacher. Students will create the star model using the classroom makerspace with help from the Teacher. Students will also complete a final *Classification Chart* that will go with the star model they have built. This will all be accompanied by a backdrop of cardboard and galaxy paper, as well as a one-page writing assignment about the story of their star they have created. The STEM projects will be presented as a whole class. This project will give students an opportunity to apply their knowledge of stars to their own creation.

Teaching Strategies

STEM Learning

In terms of teaching strategies, it is always important to refer to effect sizes, which tell us the actual research-based data on the effectiveness of a particular strategy to determine if it should be used in the classroom. Science programs have an overall effect size of 0.48 on the effect size scale of learning strategies[169] and is therefore something we should be using in classrooms and schools consistently. Science, Technology, Engineering and Math and the overall model of STEM incorporation in the classroom will guide our instruction for this unit. Students will gain scientific content knowledge about stars, and will incorporate technology through online exhibits, as well as interactive presentations and research tools. Students will apply engineering methods to create their star model, by creating the simple circuit and the model. Students will use mathematical principles to identify and list the size, mass and distance of their star.

Concept Mapping and Interactive Journaling

Concept mapping has an effect size of 0.64 on the effect size scale of learning strategies and has therefore been proven to be highly effective in terms of student learning outcomes.[170] Students will use a concept map and an interactive journaling to catalog the information they learn about stars from class. The concept map will allow students to have an overall visual of what a star is, and the components and characteristics we will be learning about. This will also help them to organize their thoughts as they will get a similar map to make a first draft for their final project.

Maker Space

One of the strategies that will be used in our classroom during the implementation of this curriculum unit, is the use of a *makerspace* or a space for students to create in the classroom using provided materials. A makerspace is meant to be a truly authentic creation space where students are provided the materials to construct STEM models. Students will rotate through using the makerspace to assemble parts of their star that they will create and classify. The maker space will include all the necessary STEM materials for them to create their star model. This space will also include STEM guidelines and instruction. The maker space allows students to have a space to engage in engineering and design in the classroom.

Classroom Activities

Charting the Stars: The STEM Planning Process

Objectives

The students will complete the planning process for creating their star model.

Materials

- STEM Scientist Notebook
- My Star Planning Document
- The class Hertzsprung-Russell Diagram

Procedures

During this activity, students will be using their knowledge about stars and their characteristics in class, to gradually plan out the different characteristics of their star. One of the first things students will do, will be to pick a star color. This will then determine the rest of their characteristics. Students will plan out these characteristics of their STAR on a Planning Document. This will be the *first draft* of their star planning. Once students have completed the planning document, they will use a class size

Classifying our Stars: Using Interactive Notes and Organizers

Objectives

The students will use interactive notes and a graphic organizer to plan their Star Model Classification Display.

Materials

- STEM Scientist Notebook
- My Star Classification Graphic Organizer

Procedures

This activity will be ongoing throughout the implementation of the curriculum unit. Students will use their STEM Scientist Notebook to keep detailed notes on the information we learn about the universe, galaxy and the solar system. Most importantly, students will keep detailed information about stars, their classification and characteristics. This information that the students collect in their notebooks about star classification, will be used as a guide for them during their project. The students will then use a graphic organizer, that will be used as a *second draft* of their star classification planning. Students will use this graphic organizer to make their final Star Classification Chart for their culminating project.

Creating a Star: Makerspace Learning

Objectives:

The students will use a classroom makerspace, to build their model of a star.

Materials:

- Makerspace Center
- Simple Circuit colored light bulb
- Varying Sized Tinted Translucent Plastic Orbs
- Small Cardboard box
- Small Cardboard trifold
- Galaxy Paper
- Light switch
- Tissue Paper
- Small Letter Stickers

Procedures:

This stage of the curriculum unit will be when students begin to create their models of stars. Students will use their planning documents for their star to assemble a star out of the items above in the makerspace. The teacher will model for students how each item can be used. The colored bulbs, varying sized plastic orbs for around the bulbs and the switch will be used to make the actual star center that glows. The colored tissue paper that will correspond with star color, will be used to show varying degrees of brightness. The cardboard box, small cardboard trifold, galaxy paper, small letter stickers will be used to create the backdrop and base for the star.

Teacher and Student Resources

The following resources will be utilized in the classroom with this unit, to enhance the instruction and provide more support for learning. I recommend the following resources for the implementation of these concepts.

NASA Interactive Solar System Exploration & Nasa Interactive Timeline of a Star

A type of resource that we will be using in class during this unit, will be NASA interactive resources. NASA has provided resources that are fully interactive and allow the teacher and student to explore the different parts of the solar system by clicking on different locations. The other interactive source that we will use most heavily, is the interactive timeline provided by NASA for the life span of a star. The NASA Interactive Solar System: https://solarsystem.nasa.gov/solar-system/our-solar-system/overview/ NASA Star Timeline: https://exoplanets.nasa.gov/life-and-death/chapter-1/

Star Sounds Slides and Videos

We will be listening to and utilizing the star sounds slides that were provided in the Yale seminar by Dr. Basu, along with other videos, to listen to star sounds. This will give students a chance to listen to the different sounds that different sized stars make. This will also allow students to work more within the scientific process standards that are the goal of this unit.

The Lives of Stars by Ken Croswell

The book entitled: *The Lives of Stars* by Ken Croswell will be used in our classroom daily during this unit, as it breaks this information down into a student friendly manner. This text also includes a very comprehensive version of the Hertzsprung-Russell diagram for us to use in class. This will be very important for the segment of the unit that will be based in star classification.

Extensions

The first extension to this Unit will be a history and science cross-curricular component about the early civilizations that studied the universe and astronomy. These civilizations include: the Mayans, Mesopotamia, India, China, Greece, Arabia.[171] Along with these civilizations, some early figures of astronomy we will discuss are Nicolaus Copernicus, Tycho Brahe, Johannes Kepler, Galileo Galilei and Isaac Newton.[172] We will learn about each of these civilizations and contributors in the warm-up section of each day of the introductory segment to this unit. We will also complete as a unit extension, *Astronomers Among Us: Looking at Famous African American, Latin and Indigenous leaders within Astronomy*, students will be learning about famous African American astronomers, as well as astronomers from cultures around the world.

Conclusion

In conclusion, this unit will be exciting for my classroom, as it will allow students to explore their solar system, their galaxy and their universe during the school year, in an engaging way. The STEM model and maker space being used in our classroom with the unit will allow students to apply the concepts of design and engineering in the classroom as well. This unit will be very special, to teach and learn that we are made of star stuff and that it is a part of who we are.[173] The goal is that this will allow students to feel more connected to what is around them, as well as their past, present and future. My students are all stars themselves and they make up the beauty of the universe and they will shape our future.

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Appendix on Implementing District Standards

Information Provided by:

VDOE. Virginia Department of Education

https://www.doe.virginia.gov/testing/sol/standards_docs/science/index.shtml

SOL 4.1:

The student will engage in the scientific process in the following ways:

k) data are communicated with simple graphs, pictures, written statements, and numbers; l) models are constructed to clarify explanations, demonstrate relationships, and solve needs; and m) current applications are used to reinforce science concepts. This unit will allow students to be able to engage in the STEM process in class, which will allow them to engage in these specific parts of the scientific process. Students will be representing data and classification information about their stars in a chart format, along with pictures and statements. Models will be constructed, and students will be able to apply their science knowledge.

SOL 4.7:

The student will investigate and understand the organization of the solar system. The students will be learning about the solar system within this unit in a more engaging way. With this unit, students will be learning about the stars as well as the rest of the solar system, so that they get more information than they would normally on the planets typically discussed in class and the sun.

SOL 4.8:

The student will learn about earth patterns, cycles and changes by learning about the:

d) the relative size, position, age, and makeup of the Sun. In this unit, we will spend a great deal of time discussing the various characteristics of stars. As the sun is a star, this will allow students to engage with this standard more thoroughly as well.

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