



Curriculum Units by Fellows of the National Initiative

2020 Volume V: Caretakers versus Exploiters: Impacting Biodiversity in the Age of Humans

One Clover and A Bee: The Impacts of Bee Sustainability on Biodiversity in Allegheny County

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Introduction

To make a prairie it takes a clover and one bee,

One clover, and a bee,

And revery.

The revery alone will do

If bees are few.

-Emily Dickinson¹



Figure 1 One clover and one bee make for revery.

Why should we preserve biodiversity? It seems like such a loaded question with the current events of a global and likely zoonotic pandemic afflicting the world at this moment. Intuitively, I believe that it is our responsibility to be better caretakers of the planet, to ensure Earth's biodiversity is preserved for future generations; however, is there an argument that we should exploit Earth at all costs to feed and provide energy for the growing human population? Students will discuss the importance of maintaining ecosystems and will learn about the various arguments that people make in favor of preserving the Earth's biodiversity.

A great entry event would be a field trip to the Phipps Botanical Gardens and/or Pittsburgh Zoo. The project workflow will have students view photos of endangered species on the Internet and discuss the reasons why these animals are threatened and why they should be protected and ask students to explain why all the members of an ecosystem are important. As a Geometry class, we will determine why the hexagon is the strongest shape and why it is nature's most efficient shape. Locally, we will investigate human activities (use of pesticides, landscaping for agriculture (mono-cropping)² and condos, climate change, relocating nonnative bee species) and colony collapsing disorder (Varroa mites and deformed wing virus) concerning Pennsylvania bees (Agapostemon sweat bee, American bumble bee, Augochlora sweat bee, bicolored Agapostemon sweat bee, common eastern bumble bee, eastern carpenter bee, golden northern bumble bee, leaf-cutter bee, long-horned bee, mason bee, small carpenter bee, sweat bee, tri-colored bumble bee, two-spotted longhorn bee). Once students have a foundational understanding and appreciation of bees, we will examine reasons for their decline. Students will learn about the research into the main disease, Varroa mites and deformed wing virus, that is killing bees and what is being done to help them. Students will evaluate data and consider the impacts that an environment without bees might look like, including the human costs such as the impact on food production and the increased use of pesticides.

The University of Pittsburgh was officially certified last spring as Bee Campus USA through the nonprofit Xerces Society for Invertebrate Conservation. I am looking forward to having the students examine the many ways that bees and humans impact biodiversity, and whether they have an obligation as caretakers who preserve other species even for purely aesthetic reasons versus exploiters that ruthlessly modify Earth on their 'evolutionary path' as a species. I await the opportunity of discovery through research where the students consider how climate change/global warming effects or alters the ecosystem, the bio geography and behavior of species - including humans.

Rationale

I believe that the classroom is one of the few environments where social justice and equity can exist. As an inner city, public school educator I am morally obligated to advocate for the students who are underserved. At Brashear, where the student population is approximately 42% Black, 36% White, 11% Asian, 5% Hispanic, & 6% two or more races, it is important that students have a voice and a choice on how they are receiving their education. In 2014, I was part of the two-year DEbT-M (Designing for Equity by Thinking in and about Mathematics) cohort where educators address racially based inequities in secondary mathematics education in the United States. We spent two years building an understanding of the opportunity gaps and the inequitable teaching practices. We became empowered as change agents to disrupt these inequitable practices and improve mathematics teaching and learning in ways that provide students of color with more

equitable opportunities in mathematics.

As a mathematics teacher at Brashear high school's STEAM academy, we have the distinct opportunity of using 90 minutes during our block scheduling to implement project-based learning. Ever since our insightful principal, Ms. Kimberly Safran, presented the documentary "Most Likely to Succeed" back in 2015 to the entire staff, we have been exploring compelling new approaches that aim to reimaging education as we know it. Brashear has developed a STEAM Academy within its curriculum offerings that consists of ten dedicated educators and approximately 250 (out of approximately 1,300) inspiring students that desire to revolutionize what education is capable of achieving through inquiry-based learning or learning by doing.

Content Objectives

The students that will be enrolled in my Geometry classes for the 2020-2021 academic year will be mostly sophomores whom I've had the honor of teaching as freshman. As freshman enrolled in the STEAM Academy at Brashear High School, they will have successfully passed Biology. The content background may be a refresher for the most part.

Throughout the unit, the students will comprehend how ecosystems change. Students will gain knowledge of fundamental concepts within conservation and biodiversity; therefore, develop a greater sensibility of the wonderful natural world that is still surrounding us by identifying the role of caretakers and exploiters to an ecosystem. Students will gain knowledge of the main threats to biological diversity and the ability to evaluate the effects of human influences such as habitat fragmentation, climate changes and invasive species on biodiversity. Students will also gain a greater understanding of the relationships and conflicts between social development and conservation of ecosystems as well as moral and ethical issues.

Nature's finest mathematicians are bees. They can comprehend the roundness of the earth and calculate angles while communicating through a waggle dance that involves a figure eight. One of the most mathematically efficient architectural design around is the beehive that contain hundreds of hexagons. The unit will begin with an introduction to bees through literature using Mobi Warren's book "The Bee Maker." A wonderful story set in the not-too-distant future that intertwines Greek mythology and Japanese origami.³ Students will discuss and record what they already know about bees, including stories of their own bee experiences and feelings. This will be followed by several lessons on bee physiology and behaviors, as well as their role in the ecosystem. I will attempt to build a local connection to any current scientific research and conservation agencies working with bees in our area (University of Pittsburgh is certified as a Bee Campus). This would be an excellent time to have students visit, or be visited by, a presenter. This unit will symbolically be taught in the spring.

As caretakers, we will try to promote a healthy population and attract bees to our area by designing nest sites. To make these, students will need to research and design nest sites that will be appealing, attractive, and functional. We may construct one out of wood and other materials as a class to be placed on the school grounds, and I may have students build their own smaller versions to take home (depending on time, materials, etc....). Either way, successful construction and usage by local bees will be based on student research, including bee physiology and behavior, local bee activity observations, and careful material selection, nesting site design, and construction. Students have access to tools and materials and have been

trained to use them in our STEAM lab. Finally, students will observe their bee nesting site for signs of bee activity and evaluate the effectiveness of their design, construction, and placement of the site.

In summary, students will learn about a variety of bees and their roles as pollinators. Then they will focus on the different species of bees in Pennsylvania and the reasons for their decline due to human reasons. They will examine the multiple ripple effects of a healthy bee population as well as a decimated or extinct bee population. Finally, as caretakers, they will contribute data collection as well as design, construct, and evaluate the effectiveness of researched-based nesting site of their own making.

Background Content

This unit will be written based on the knowledge I have gained in the 2020 Caretakers versus Exploiters: Impacting Biodiversity in the Age of Humans seminar in addition to my own research of bees and the reasons for their decline. I will provide background information on bee physiology and behaviors, background information on the factors of their decline, a description of conservation steps that are being considered, as well as steps our governments have taken to address these issues, and background information on the various ways the reduction or complete extinction will impact other species, including humans

What is Biodiversity

Biodiversity is the shortened form of two words “biological” and “diversity.” It refers to all the variety for life that can be found on Earth) plants, animals, fungi and micro-organisms) as well as to the communities that they form and the habitats in which they live. Biodiversity includes the diversity within species and between different species within terrestrial, freshwater and marine ecosystems. An ecosystem is the name given to all living species that live together in a stable community, interacting with one another and their physical environment. Ecosystems need a balanced and diverse number of species to thrive. Biodiversity plays a critical role in sustaining human populations across the globe. We depend on it for sustained food growth, for clean air and water and for medicine and for shelter.⁴ Biodiversity enriches our lives – it has economic, cultural, recreational, religious and aesthetic importance across the world.

Biodiversity is under serious threat as a result of human activities. The main dangers worldwide are population growth and resource consumption, climate change and global warming, habitat conversion and urbanization, invasive alien species, over-exploitation of natural resources and environmental degradation.⁵ While there might be “survival of the fittest” within a given species, each species depends on the services provided by other species to ensure survival. Evidence shows that a sixth mass extinction is occurring now. Unlike previous mass extinctions, the sixth extinction is due to human actions. This period during which human activities have impacted the environment from global warming, habitat loss, changes in the chemical composition of the atmosphere, oceans and soil, and animal extinctions to constitute a distinct geological change is defined as the Anthropocene.

Biodiversity boosts ecosystem productivity where each species has an important role to play. For example, many plant species mean a greater variety of crops, greater species diversity ensures natural sustainability for all life forms, and healthy ecosystems can better withstand and recover from a variety of disasters. A healthy biodiversity provides several natural services for everyone. Ecosystem services such as protection of

water resources, soils formation and protection, contribution to climate stability, and maintenance of ecosystems. Biological resources such as food, medicinal resources and pharmaceutical drugs, and diversity in genes, species and ecosystems. Social benefits such as research, education, recreation, tourism and cultural values.⁶

Characteristics of the Bee

Most bees have short, thick bodies covered with hair, six legs, and three body parts: head, thorax, and abdomen. They have two pairs of wings. One pair is attached to each of the last two segments of the thorax, but front and back wings are joined so that they may look like only one. The rapid movements of the wings make a humming sound in flight. Bees wings flap about 200 plus beats per second. These insanely rapid wing movements cause the air to vibrate.⁷ With three single eyes on top of their heads and two huge, helmetlike compound eyes, bees can see color, pattern, and movement. The honeybees' antennae serve as their temperature indicators. From their thermometers, the bees receive signals telling them what needs to be done to keep the hive safe and comfortable. If the colony gets too warm, some of the bees' form living chains and cool the air with the fanning of their wings. There are bees that collect water, which also will lower the temperature of the nest as the water evaporates from the surfaces of the honeycomb. Simultaneously, a watery substance, probably from their honey filled stomachs, evaporates from their mouths. In the opposite spectrum, if it gets too cold outside, the bees raise the temperature of the nest by clustering very closely together. Colonies part ways in the fall and only the young queens, who have mated, remain to hibernate; all others pass away. In the spring, after emerging from hibernating quarters in the litter or soil, the queen looks for a place to nest, which may be under rocks, on or below the ground surface, in the abandoned nest of a mouse or bird, in a clump of grass, and makes preparations for her first brood. In the case of the first brood, egg cells are fabricated, usually of pollen, and one egg is laid in each cell. One or more cells are manufactured of wax and pollen and filled with honey before the young arrive. There are three distinct castes among social bees: The drone, (which is male), the worker (which is an infertile female), and the queen (which is a fertile female). After the workers arrive, commonly the first brood, the queen isolates herself to egg laying while her infertile female workers forage and enlarge the nest, constructing brood cells, building and storing honey and pollen pots, caring for the young. Brood cells are not used again, but cocoons are used for storage of honey and pollen after undergoing alterations. In some colonies the second brood is all male and the third brood is female. Workers of the later broods become progressively larger. The queens and males usually leave the nest and fly off to mate. Males are often seen flying about the entrance at this time, waiting for the young queens to come out.

Colonies of honeybees (*Apis mellifera*) are maintained throughout the winter by their habit of storing honey and clustering. When a bee collects nectar from the flower of a plant, the pollen sticks to the hair of the bee's body. Some of this pollen is rubbed off when it visits the next flower. When this happens, fertilization is possible and a fruit carrying seeds can develop. Bees need to visit close to two million flowers and plants to produce about one pound of honey.⁸ Each of those bees in their lifespan can produce one twelfth teaspoon of honey. Often bumblebees work from dawn to dusk, visiting twenty to forty flowers per minute. The population of workers in a hive of honeybees may be 20,000 to several times this number. By continued movement of wings, legs, and bodies and the normal process of metabolism, enough heat is generated to keep the compact cluster of individuals alive. They draw closer together as the temperature drops and shift their position to gain access to more stores of honey. The queen remains within the cluster and by early February begins laying eggs. As the days grow longer and warmer, the cluster will enlarge, and drones are produced in preparation for the division of the colony. The worker broods are kept in the lower central part of the comb, and the pollen stored around them in cells of the same size. The larger cells of the drones are usually in the

lower corners of the comb. Honey is stored in cells of the same size toward the back of the hive. Queen cells are large thimble shaped cells which hang down vertically from the brood comb. Brood cells are kept open and the larvae fed daily. All get royal jelly, a secretion of the workers, for two days. Workers and drones are then given honey and pollen while queens remain on the royal jelly diet. The white grublike larva is full grown and fills its cells in about six days. The cell is capped, and the larva pupates after spinning a cocoon. Pupation requires about seven and one-half days for queens, twelve days for workers, and fourteen and one-half day for drones. Swarming by honeybees occurs when new queens appear in the hive, prompting the mother queen to leave and half the colony to follow her. They cluster on a limb or other overhang and remain until the scouting bees find a new home. In the parent colony the new queens fight one another until only one remains alive. The survivor flies out to mate and returns as the new queen mother. Young workers first serve as nurses, later produce wax, and after about three weeks of various chores in the hive become foragers. Workers live about six weeks during the peak of activity. The queen is fed royal jelly throughout her life, which lasts a year or more. Drones are fed honey if it is plentiful but are ousted from the hive when they become a burden. Their life span is about eight weeks.

The main types of bees in the US are honeybees and bumblebees. Our bumblebees are native species, but honeybees are descendants of bees brought over by early settlers. Native Americans used to call them “white man’s flies.” There are twice as many bee species as bird species⁹ and they are generally grouped into the Apidae family.



Figure 2 “The busy bee has no time for sorrow.” -William Blake

The “B”ee in Biodiversity

It was around 2006-2007 that beekeepers raised the alarm that thousands of beehives were alarmingly empty. It wasn’t just in the US that was losing beehives because it seems that similar issues were occurring all over the world with beekeepers. In 2018, the United Nation with the lead from Slovenia introduced May

20th as the official World Bee Day to draw attention to the importance of bees and biodiversity.¹⁰ This date was significantly chosen for Anton Jansa's birthday, who was a Slovenian apiculture pioneer from the 1700s. Apiculture is derived from the Latin word 'apis' which means bee and is the scientific method of caring and management of honeybees for the production of wax and honey. One of Anton Jansa's most notable work includes a posthumous 1775 publication of "A Full Guide to Beekeeping" where he wrote "Among all God's beings there are none so hard working and useful to man with so little attention needed for its keep as the bee." Bees are pollinators that play a part in every aspect of an ecosystem. Growth of flowers, trees, and other plants which serve as shelter and food for creatures small and large are supported by bees. Without bees, our plates would be empty because our gardens would be bare.

Known for their elaborate hives, bees also help build homes for millions of other insects as well as larger animals. Tropical forests, temperate deciduous forests, and savannah woodlands are vital to the bee's role as pollinators because the tree species in these ecosystems couldn't grow.¹¹ Bees feed their colonies during the cold winter months by producing honey. As humans we have harvested this sweet snack for thousands of years, but humans aren't the only ones who delight in its nutritious treat. Besides Winnie the Pooh and Baloo from "The Jungle Book," birds, opossums, racoons, and other insects will raid beehives for a taste. Bees are also part of an ecosystem's food chain. Many species of birds and insects such as spiders, dragonflies and praying mantises' prey on bees for nourishment. Bees are also accountable to produce many seeds, nuts, fruit, and berries that serve as a vital good source for wild animals.¹²

The Importance of Pollination

If you love broccoli, asparagus, melons, cranberries or apples you should thank our fuzzy insect friends. These plants require the transfer of pollen which bees move from flower to flower in their search for nectar. And because bees are social insects, they are not going to eat this food themselves, they are going to return to their hive and use the nectar, the lipids, and the proteins found in the pollen and feed the hive. About 1 out of 3 crops and ninety percent of all plants require cross pollination to spread and thrive. Bees are one of the most important pollinators with no disrespect to moths, beetles, flies, ants, butterflies, and wasps. Pollination is a fundamental process that forms the basis for much of our terrestrial biodiversity. IPBES 2016 published that \$577 billion rely on animal pollination.¹³

Factors of Their Decline

Over the past two decades, bee declines worldwide have drawn international attention. Many bumble bee populations have gone locally extinct, resulting in dramatic range contractions. Recent surveys of Pennsylvania beekeepers have recorded a statewide loss of 44.5% of colonies in the winter of 2016-2017.¹⁴ It's complicated to pinpoint why bees are declining and how we can help them. One factor is the availability of food and nest resources due to intensive farming practices such as mono-cropping or landscaping with condos and strip malls. Another factor is the incidence of antagonists.¹⁵ Flowers are the watering holes of the pollinator world offering a place for other pollinators and their parasites (Varroa mites and deformed wing virus) to encounter each other. This mite is sort of like a tick that transmit diseases to humans and other mammals. One of the diseases that it will transmit is a virus called deformed wing virus that causes the adult bees to emerge with shriveled wings. That poor bee will never be on an apple tree, she will never go and collect nectar and pollen for her hive, and as a result, the hive will suffer.

Climate change causes some flowers to bloom earlier or later than usual, leaving bees with fewer food sources at the start of the season.¹⁶ Bees suffer habitat loss from development, abandoned farms, and the lack of

bee friendly flowers. When flowers are abundant, pollinators select their favorite or most energetically efficient flowers and therefore are less likely to share flowers with other species. As flower abundances decline due to habitat loss and/or climate change, pollinators forage from a greater diversity of plants, potentially meeting many more individuals and increasing parasite transfer. Some colonies collapse due to plants treated with neonicotinoid pesticides. Neonicotinoids are slow-release, agricultural pesticides that attack the central nervous systems of insects. Honeybees seem to prefer neonicotinoid-laced nectar and become so inebriated they have difficulty finding their way home.

Conservation Steps

Conservation practices designed to help honeybees and other pollinators also help reduce erosion, increase soil health, control invasive species, provide quality forage for livestock, increase populations of other beneficial insects and wildlife and make agricultural operations more efficient. Mowing less frequently can improve pollinator habitat and can be a practical and economical alternative to lawn replacement.¹⁷ Other practices include not using pesticides in your garden, buying local raw honey, plant your garden with native and bee friendly plants, don't weed your garden, and even if you just have a small balcony you can install a little water basin for the bees to drink during the summer.



Figure 3 A bee descends into the sweetness of a white apple blossom.

One of the biggest environmental impacts of the global shutdown due to the pandemic has been the significant reduction in air pollution. Less fumes from cars on the road makes it easier for bees to forage as air pollution substantially reduces the strength and longevity of floral scents. Pollutants break down scent molecules emitted by plants, making it harder for bees to detect food. In a world with less air pollution, bees can make shorter and more profitable shopping trips and this may help them rear more of their young.¹⁸ Ecologists and conservation groups have called on the wider public to help them gather scientific data during this time. Citizen science is vital and anyone can participate in the scheme by completing what is known as a Flower-Insect Timed Count (FIT Count). This involves monitoring a small patch of flowers in your garden for 10 minutes, counting the number of insects you see and filling in an online form. People are beginning to realize how their mental health and well-being is supported by nature.¹⁹

Bees Are Nature's Mathematicians

Bees use a sophisticated communication system that is unique and allows the coordination of an entire beehive of up to 20,000 to 80,000 individual bees that include a single queen, several male drones and mostly female worker and forager bees. This efficient form of communication is referred to as the waggle dance.²⁰ Once a forager has discovered what she determines to be a good patch of flowers, a new nesting site, or a good source of water she returns back to the hive and begins her dance. Upon landing, her body waggles forward very quickly from side to side forming a circle, she then stops at her certain position and either turns to the left or the right of that circle and performs another waggle run to form a figure eight. There are two vital pieces of information that is communicated to the colony: direction and distance. The way she is facing when she's doing the waggle dance communicates direction. If she dances at about 270 degrees from up, this communicates that the new resource is located 270 degrees from where the sun is on the horizon. The duration of the dance communicates distance where about one second represents about 250 feet. To make a case for her determination, this bee will waggle dance more figure eight runs to convey to the colony that her newfound resource is of high quality. As a leaderless democracy, the hive will observe other foragers waggle dances that are casting their vote for the new site located and they themselves go out to explore these possibilities. They will then return and mimic the waggle dance that they voted for that represent the best source of survival for the colony. Based on majority rule, the entire assemble will depart and fly together to their new resource.

Mathematically, bees are good at weighing the cost of a longer distance flight against the benefit of the resource. Bees are blessed with a very reliable twenty-four-hour clock that is seldom affected by anything and does not seem to depend on events in the outside world to keep it working. Bees also can measure very short units of time, down to mere fractions of a second. They use their internal clock sense to arrive at the right time for the opening of a flower that offered a generous serving of nectar the day before. The biological clock is also a very important part of a bee's direction-finding equipment. When a foraging bee leaves the hive to look for nectar or pollen, an almost unbelievable process begins. Flying at a speed of perhaps thirteen miles an hour, the bee's eyes sense its flight speed in relation to the ground and somehow measure the direction of its flight compared to the angle of the sun. On a heavily overcast day bees seem confused, presumably because there has been no glimpse of the position of the sun. But on a partly cloudy day, a bee can use a small patch of blue sky as its direction finder. This is possible because bee's eyes detect polarized light. Bees also see the entire pattern of the sky at once, for their compound eyes are made up of thousands of tiny facets.

Nature Adores the Number Six and Bees Adore Hexagons

Let's take a little tour of the all-pervasive hexagons in nature on a massive scale down to its ethereal existence. There's a substantial cloud formation on Saturn's north pole. Far from an ordinary cloud formation, it is a unmistakable hexagon. Each of the sides of the six-sided polygon is bigger than the Earth's diameter.²¹ One of the many hypotheses about its mysterious cause is a weather whirlpool spinning so fast that it turns into a hexagon. Returning to Earth, there are plenty examples of basalt columns which are found in California's Devils Post Pile, Wyoming's Devils Tower, the Cliff of Stone Plates in Vietnam and similarly in Northern Ireland's Giant's Causeway. Basalt columns or columnar jointing forms when lava or types of rocks undergo cooling and contraction which leads to cracks that were burdened with tension. These cracks just happen to release the most tension at around 120 degrees which is magically the interior angle of a regular polygon.²² Snowflakes utilize the hexagonal structure. The molecules in frozen water crystals become hexagonal because of its molecular structure. To break it down even further, most organic compounds have a

carbon foundation. Carbon is bountiful and bonds well with other elements. But when six carbon atoms are bounded together, the bond angle is at an even 120 degrees and forms a perfect hexagon known as the benzene ring.²³ Then there's the bees themselves. The reason that bees can see the entire pattern of the sky at once is because the eyes of bees are made up of hundreds and hundreds of hexagonal lenses. On some level the hexagon is encoded into their spirit and the most notable proof of that are the honeycombs found in every beehive around the world.

The Honeycomb Conjecture

The most important feature of a bee's life is the hive. Like humans, bees require food and shelter to survive. Bees demand a secure place for the entire colony to live while at the same time a place where they can store their nectar to ripen into honey; therefore, space efficiency is of utmost importance. A marvelous solution is to build tiny storage cells just wide enough for a bee to fit and doubles as a storage space for their nectar. The cells are made from wax which the bees produce themselves through their glands by converting the sugar from the honey. The dilemma is that it requires a great deal of energy to produce their own wax because the bee themselves have to consume about eight ounces of honey to produce about one ounce of wax.²⁴ Efficiency is of supreme importance to a bee's survival. Through evolutionary architecture, the bees designed an efficient space that allows them to store the largest possible amount of honey while using the least amount of wax, hence the hexagonal prism we call honeycombs. In geometry, a conjecture is basically a conclusion or opinion which is suspected to hold truth without confirming evidence. The honeycomb conjecture asserts that a regular hexagonal grid is the best way to divide a surface into regions of uniform area with the least total perimeter. This conjecture dates as far back as 36 BC and in 1999 was proven to be true by University of Pittsburgh professor and mathematician Dr. Thomas C. Hales.²⁵

$$\limsup_{r \rightarrow \infty} \frac{\text{perimeter}(C \cap B(0, r))}{\text{area}(C \cap B(0, r))} \geq \sqrt[4]{12}$$

Let Γ be a locally finite graph in R^2 , consisting of smooth curves, and such that $R^2 \setminus \Gamma$ has infinitely many bounded connected components, all of unit area. Let C be the union of the bounded components. Equality is attained for the regular hexagonal tile.

Classroom Strategies and Student Activities

The initial "hook" for this curriculum is a field trip to the Pittsburgh Zoo & PPG Aquarium. During the zoo visit students will gather information about three animals with various statuses. Students will have to describe concerns, treatments, and what can be done to support these species. In the zoo, students will also try to evaluate the enclosure and the behavior. We will explore the purpose of zoos and make a critical review of the impact on conservation.

Another initial "hook" for this curriculum is a field trip to the Phipps Botanical Gardens. During the botanical visit students will gather information about three flowers with various statuses. Students will have to describe concerns, treatments, and what can be done to support these species. In the garden, students will also try to evaluate the enclosure. We will explore the purpose of botanical gardens and make a critical review of the

impact on conservation.

Activity One - Dinner and a Movie/Book.

This idea was inspired from Sean Means' "The American Dream" curriculum unit from 2018. The dinner and a movie/book model allow students to view/read and reflect on full-length films/books that are relevant to what we are currently studying. The film/book will be shown/read after school in the interest of instructional class time. Students will be more likely to attend films and read books that are more modern in addition to receiving participation/extra credit. And of course, pizza will be served.

Activity Two - Journaling (writing marathons: ascending intervals - 3min, 5 min, 7min, 10min) & Read Aloud (both student and teacher).

This idea was inspired from Lauren Freeman's "Becoming Butterflies" curriculum unit from 2019. I've learned through my years as a mathematics teacher that a student's math competency is directly related to their mother's reading skills. That's simply amazing and I hope to develop the students reading skills and (more importantly) their listening skills through this exercise.

Activity Three - Geometry and Biology through art expression.

One of my favorite things about teaching geometry is that the subject lends itself to incorporating art. Students will discover fascinating relationships between geometry and nature: mandalas, MC Escher drawings, the golden ratio, theory of proportions, flowers, shells, marine life, origami, and the human face. An example of what this would look like would be origami bees. Origami is good for you as it develops eye hand co-ordination, sequencing skills, math reasoning, spatial skills, memory, but also patience and attention skills.

Activity Four - Think Marks

Think marks is a strategy that incorporates quick and simple doodling. From infancy to industry, doodling has practical and powerful applications where students from all walks of life give visual representation and meaning to their ideas and to help others. In using this tool, students are able to show their thinking as they read or solve math problems. For example, if a student is reading an informational text about the Honeycomb Conjecture and something is confusing, the student might place a question mark to signal they are confused.

Activity Five - Project Bee Watch

Project Bee Watch is a citizen science project that leverages volunteer labor to understand how pollinators are faring in Allegheny County. At the Frick Environmental Center, operated by the Pittsburgh Parks Conservancy, students will receive manuals to help them identify pollinators and the plants that attract them. Each student will receive 3.3 feet by 3.3 feet plot. It's a tool composed of bamboo sticks tied together with a string. The square is used to mark off the section of wildflowers where the data will be collected. It only takes ten minutes to complete a survey and students can do it as much or as little as they want.

Activity Six - Tessellations

This activity examines tessellations and ways of covering a plane with the same two-dimensional polygons so that there are no overlaps or gaps. Tessellation is a pattern of shapes that fit perfectly together and are found all over the place especially in bathroom and kitchen tiles, in the living room on carpets and wooden floors, and especially where brick is used for construction. Students will explore tessellations by using regular

polygons to discover which shape tessellates and which shape does not. Students will be using this table:

Regular Polygon	Sketch	Tessellate?	Why? Or Why not?
Equilateral Triangle			
Square			
Regular Pentagon			
Regular Hexagon			
Regular Heptagon			
Regular Octagon			

Allow the students to approach the problem in any way that they like. They need to be able to justify why there must be gaps or why the pattern can't go on infinitely. Bring the class back together to discuss and share the justification of their results. As a connection into the Honeycomb Conjecture, ask the class if they have a conjecture about which regular polygon can be used efficiently to cover the most area with the least perimeter. Each conjecture can be explored with the use of grid paper.

Activity Seven - 3D Tessellations

This activity allows the students to explore three-dimensional shapes, describe and identify their distinguishing features, and most importantly, appreciate the efficiency of the tessellating hexagon in meeting the needs of honeybees. Engage the students with a display of an actual honeycomb and ask: How does the honeycomb benefit the bees? Discuss and record the student's understanding of the key ideas. Students will recognize that it takes a lot of energy for bees to make wax, the hexagonal prism is more efficiently arranged, and that the honeycomb has been proven by science and math to be the perfect combination of saving energy through wax and honey storage which allows the bees to stay alive.

Figure 4 Bee on honeycomb in hive.

Activity Eight - Culminating Activity

Suggested student assessment would be to have each group choose one of its conservation ideas and write a plan for how the class could carry the idea out. It must consist of an explanation of why the plan is a good one and what it will accomplish, a list of the species that will benefit from the plan, and a description of the difficulties that might be associated with this plan.

Notes

¹ Emily Dickinson, "To Make A Prairie," in *The Poems of Emily Dickinson*, ed. Ralph W. Franklin (Cambridge, Massachusetts: The Belknap Press of Harvard University Press, 1998)

² FAO of United, Nations. "Declining Bee Populations Pose Threat to Global Food Security and Nutrition." May 20, 2019. Accessed July 13, 2020

³ Warren, Mobi. *The Bee Maker*. Pennsauken: BookBaby, 2019.

⁴*An Introduction to Biodiversity*. Arizona State University Center for Biodiversity Outcomes. Accessed July 15, 2020. <https://sustainability.asu.edu/biodiversityoutcomes/biodiversity-introduction/>.

⁵ "Major Threats." Accessed July 15, 2020. biodiv.be/biodiversity/threats/#:~:text=Biodiversity is under serious threat,natural resources and environmental degradation.

⁶ Shah, Anup. "Why Is Biodiversity Important? Who Cares?" January 19, 2014. Accessed July 15, 2020. <https://www.globalissues.org/article/170/why-is-biodiversity-important-who-cares#:~:text=Biodiversity boosts ecosystem productivity where,an important role to play.&text=A larger number of plant, sustainability for all life forms.>

⁷ Miley, Jessica. "The Buzz of Bees Explained." *The Buzz of Bees Explained*. February 27, 2019. Accessed July 12, 2020. <https://interestingengineering.com/video/the-buzz-of-bees-explained#:~:text=But first the flying sounds,vibrate which translates to sound.&text=During buzz pollination, a bee's, it sits on a flower.>

⁸ Weaver, Maggie. "#FeedABee Initiative in Allegheny County Gives Bee Colonies Plants and Land to Stay Fed." March 20, 2019. *Pittsburgh City Paper*. <https://www.pghcitypaper.com/pittsburgh/feedabee-initiative-in-allegheny-county-gives-bee-colonies-plants-and-land-to-stay-fed/Content?oid=14209867>.

⁹*What's Happening to The Bees? Why Are They Important*. Directed by Ignasi Bartomeus. Performed by Ignasi (Nacho) Bartomeus. *What's Happening to the Bees?* April 08, 2016. Accessed July 12, 2020. <https://www.youtube.com/watch?v=pnY9R-feIDA>.

¹⁰ Klein, Simon, and Andrew Barron. "Ten Years after the Crisis, What Is Happening to the World's Bees?" May 17, 2017. Accessed July 28, 2020. <https://theconversation.com/ten-years-after-the-crisis-what-is-happening-to-the-worlds-bees-77164>.

¹¹ "5 Ways Bees Are Important to the Environment." 2020. <http://www.pthomeandgarden.com/5-ways-bees-are-important-to-the-environment/#:~:text=Biodiversity,different species to co-exist.>

¹² Ibid.

¹³ Masood, Ehsan. "Battle over Biodiversity." August 23, 2018, 424-25

¹⁴ Evans, Katy C. *Tracking the Health of Feral Bees in Pa, 2018*. Lopez-Urbe Lab. September 11, 2018. Accessed July 15, 2020. <https://lopezuribelab.com/2018/09/11/tracking-health-feral-bees-pa-2018/>.

¹⁵ Miller-Struttman, Nicole. "The Complex Causes of Worldwide Bee Declines." January 12, 2016. Accessed July 15, 2020. <https://phys.org/news/2016-01-complex-worldwide-bee-declines.html>.

¹⁶ Cmons, Marlene. *With Shorter Winters, Plants Bloom Early and Die Young*. National Geographic, 19 Oct. 2018, blog.nationalgeographic.org/2018/10/19/with-shorter-winters-plants-bloom-early-and-die-young/#:~:text=Spring has been coming,winters shorter and springs warmer.

¹⁷ Contosta, Alexandra R., Joan Milam, and Christofer Bang. "Mowing the Lawn Less Often Improves Bee Habitat." Mowing the Lawn Less Often Improves Bee Habitat. March 13, 2018. Accessed July 12, 2020. <https://www.nrs.fs.fed.us/news/release/mowing-lawn-less-improves-bee-habitat#:~:text=“We found that backyards can,or even planting pollinator gardens.”>.

¹⁸ Gerretsen, Isabelle. "Why Bees Are Finally Getting a Break." May 6, 2020. <https://www.bbc.com/future/article/20200506-why-lockdown-is-helping-bees>.

Lockdowns have put a number of insect-harming practices on hold, creating a friendlier world for wild bees - and conservationists hope some of these changes could be here to stay.

¹⁹ Ibid

²⁰*Honeybee Societies and Dance Floor Democracy*. Performed by Margaret Couvillon. August 1, 2012. <https://www.youtube.com/watch?v=tcXkQBY0i0k>.

²¹ Carmichael, Joe. "Hexagons Are as Close as Science Gets to Magic." Accessed August 2, 2016. <https://www.inverse.com/article/18926-hexagons-nature-science-sacred-geometry-explainer#:~:text=Hexagons Are as Close as Science Gets to Magic&text=Believers in sacred geometry ascribe,likely by a higher power.>

²² Ibid

²³ Ibid

²⁴*Why Do Bees Love Hexagons?* Directed by Zack Patterson and Andy Peterson. June 10, 2014. <https://www.youtube.com/watch?v=QEzlsjAqADA>.

²⁵*Why Do Bees Build Hexagons? Honeycomb Conjecture Explained by Thomas Hales*. Directed by Joe Double and Tom Crawford. Performed by Thomas Hales. Tom Rocks Math. January 16, 2019. <https://www.youtube.com/watch?v=7edkFs8Vu1E>.

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"5 Ways Bees Are Important to the Environment." 2020. Accessed July 28, 2020. <http://www.pthomeandgarden.com/5-ways-bees-are-important-to-the-environment/#:~:text=Biodiversity,different species to co-exist.>

It takes more than soil, water, and sunshine to make the world green. At least 30% of the world's crops and 90% of all plants require cross-pollination to spread and thrive

An Introduction to Biodiversity. Arizona State University Center for Biodiversity Outcomes. Accessed July 15, 2020.

<https://sustainability.asu.edu/biodiversityoutcomes/biodiversity-introduction/>.

What is biodiversity and why is it important?

Carmichael, Joe. "Hexagons Are as Close as Science Gets to Magic." Accessed August 2, 2016. <https://www.inverse.com/article/18926-hexagons-nature-science-sacred-geometry-explainer#:~:text=Hexagons Are as Close as Science Gets to Magic&text=Believers in sacred geometry ascribe,likely by a higher power.>

Hexagons are startlingly omnipresent in nature and their properties are somewhat awe-inspiring.

Cimons, Marlene. "With Shorter Winters, Plants Bloom Early and Die Young." October 19, 2018.

<https://blog.nationalgeographic.org/2018/10/19/with-shorter-winters-plants-bloom-early-and-die-young/#:~:text=Spring has been coming,winters shorter and springs warmer. Spring has been coming earlier, prompting plants to sprout and turn green sooner than ever before. This is because carbon pollution has been heating up the planet, making winters shorter and springs warmer.>

Contosta, Alexandra R., Joan Milam, and Christofer Bang. "Mowing the Lawn Less Often Improves Bee Habitat." Mowing the Lawn Less Often Improves Bee Habitat. March 13, 2018. Accessed July 12, 2020. <https://www.nrs.fs.fed.us/news/release/mowing-lawn-less-improves-bee-habitat#:~:text=We found that backyards can,or even planting pollinator gardens.>

Mowing less frequently can improve pollinator habitat and can be a practical, economical, and timesaving alternative to lawn replacement or even planting pollinator gardens.

Evans, Katy C. *Tracking the Health of Feral Bees in Pa*, 2018. Lopez-Uribe Lab. September 11, 2018. Accessed July 15, 2020. <https://lopezuribelab.com/2018/09/11/tracking-health-feral-bees-pa-2018/>.

These losses are close to the winter losses reported for managed colonies in Pennsylvania by the Pennsylvania State Beekeepers Association (PSBA), which was 44.5% for the 2017-2018 winter.

FAO of United, Nations. "Declining Bee Populations Pose Threat to Global Food Security and Nutrition." Declining Bee Populations Pose Threat to Global Food Security and Nutrition. May 20, 2019. Accessed July 13, 2020. <http://www.fao.org/news/story/en/item/1194910/icode/#:~:text=Bees and other pollinators are,crop yields but also nutrition.>

Bees and other pollinators are declining in abundance in many parts of the world largely due to intensive farming practices, mono-cropping, excessive use of agricultural chemicals and higher temperatures associated with climate change, affecting not only crop yields but also nutrition.

Gerretsen, Isabelle. "Why Bees Are Finally Getting a Break." May 6, 2020. <https://www.bbc.com/future/article/20200506-why-lockdown-is-helping-bees>.

Lockdowns have put a number of insect-harming practices on hold, creating a friendlier world for wild bees - and conservationists hope some of these changes could be here to stay.

Holsopple, Kara. "BEE WATCHERS NEEDED." May 24, 2019. Accessed July 15, 2020. <https://www.alleghefront.org/bee-watchers-needed/>.

Science relies on data. It requires the time and dedication to collect and analyze a lot of information. That's where volunteers, or citizen scientists, come in. Project Bee Watch is a citizen science project that leverages volunteer labor to understand how pollinators are faring in Allegheny County.

Honeybee Societies and Dance Floor Democracy. Performed by Margaret Couvillon. August 1, 2012. <https://www.youtube.com/watch?v=tcXkQBY0i0k>.

How You Can Help save Bees, One Hive at a Time. Directed by Noah Wilson-Rich. Performed by Noah Wilson-Rich. TEDxProvincetown. March 2019. Accessed July 15, 2020. This is not just an issue for bees-rights activists. It's a food security issue. Per the BBC, bees pollinate the vast majority of the crops that feed 90 percent of us humans. Read More: https://www.mashed.com/225543/the-real-reason-almonds-are-destroying-california/?utm_campaign=clip.

Bees are dying off in record numbers, but ecologist Noah Wilson-Rich is interested in something else: Where are bees healthy and thriving? To find out, he recruited citizen scientists across the US to set up beehives in their backyards, gardens and rooftops. Learn how these little data factories are changing what we know about the habitats bees need to thrive -- and keep our future food systems stable.

Kilvert, Nick. "Scientists Modify Honey Bee Gut Bacterium to Fight Colony Collapse-causing Varroa Mite and Deformed-wing Virus." Scientists Modify Honey Bee Gut Bacterium to Fight Colony Collapse-causing Varroa Mite and Deformed-wing Virus. January 30, 2020. Accessed July 12, 2020. <https://www.abc.net.au/news/science/2020-01-31/honey-bees-insect-colony-collapse-varroa-mite-deformed-wing/11905980>.

Colony Collapse Disorder caused the loss of an estimated 40 per cent of honey bee colonies in the US last year — the worst winter decline on record for tracked hives since research began.

Klaeson, Hanna. "The Real Reason Almonds Are Destroying California." July 10, 2020. Accessed July 15, 2020. <https://www.mashed.com/225543/the-real-reason-almonds-are-destroying-california/>.

Part of it has to do with the enormous amounts of fungicides and insecticides that almond growers use, in particular, an herbicide called glyphosate which is lethal to bees. Although these substances were deemed "bee-safe," in 2019, Ohio State University researchers reported that these chemicals were lethal to bee larvae. Luckily, that realization caused many almond farmers to reduce their use of insecticides during the almond bloom. Another factor is that bees thrive in a biodiverse landscape, and almond orchards are just not that. According to The Guardian, these conditions are in part responsible for the fact that more bees die every year than all other animals raised for slaughter in the United States.

Klein, Simon, and Andrew Barron. "Ten Years after the Crisis, What Is Happening to the World's Bees?" May 17, 2017. Accessed July 28, 2020. <https://theconversation.com/ten-years-after-the-crisis-what-is-happening-to-the-worlds-bees-77164>.

Ten years on from the alarm over disappearing bees, it is fair to say we now know the nature of the problem and what can be done to fix it. It's up to us to take the steps needed to sustain these precious pollinators of our food for the future.

Klein, Joanna. "You're a Bee. This Is What It Feels Like." *You're a Bee. This Is What It Feels Like*. December 02, 2016. Accessed July 12, 2020. <https://www.nytimes.com/interactive/2016/12/02/science/bees-pollen-senses.html?action=click&module=RelatedLinks&pgtype=Article>.

Watch as a fellow bee moves in the shape of a figure eight and waggles only where the eight crosses: The angle of that waggle tells you in which direction to head out from the hive. The speed of the waggle tells you how far to go.

"Major Threats." Accessed July 15, 2020. biodiv.be/biodiversity/threats/#:~:text=Biodiversity is under serious threat,natural resources and environmental degradation.

Biodiversity is under serious threat as a result of human activities.

Masood, Ehsan. "Battle over Biodiversity." August 23, 2018, 424-25.

IPBES 2016 published that pesticides has contributed to falling bee population and \$577 billion rely on animal pollination.

Miley, Jessica. "The Buzz of Bees Explained." *The Buzz of Bees Explained*. February 27, 2019. Accessed July 12, 2020. <https://interestingengineering.com/video/the-buzz-of-bees-explained#:~:text=But first the flying sounds,vibrate which translates to sound.&text=During buzz pollination, a bee's,it sits on a flower>.

bees wings flap at up to 230 beats per second. These insanely rapid wing movements cause the air to vibrate which translates to sound

Miller-Struttman, Nicole. "The Complex Causes of Worldwide Bee Declines." January

12, 2016. Accessed July 15, 2020. <https://phys.org/news/2016-01-complex-worldwide-bee-declines.html>.

As we attempt to pinpoint why bees are declining and how we can help them, a common trope is emerging: it's complicated. For example, in a recent review in *Science* magazine, Goulson et al. (2015) point to several, interacting factors: availability of food and nest resources, exposure to agrochemicals, incidence of antagonists (i.e., disease, parasites and invasive species), and climate change.

More than Honey. Directed by Markus Imhoof. Performed by Markus Imhoof. *More than Honey*. November 11, 2013. Accessed July 12, 2020. <http://www.morethanhoneyfilm>.

why bees, worldwide, are facing extinction

Orde, Elena. "Eating Honey Is Bad for Bees." *Eating Honey Is Bad for Bees*. August 19, 2019. Accessed July 12, 2020. <https://theecologist.org/2019/aug/21/eating-honey-bad-bees>. supporting the honey industry isn't the best way to protect these incredibly important insects

Shah, Anup. "Why Is Biodiversity Important? Who Cares?" January 19, 2014. Accessed July 15, 2020. <https://www.globalissues.org/article/170/why-is-biodiversity-important-who-cares#:~:text=Biodiversity boosts ecosystem productivity where,an important role to play.&text=A larger number of plant, sustainability for all life forms>.

At least 40 per cent of the world's economy and 80 per cent of the needs of the poor are derived from biological resources. In addition, the richer the diversity of life, the greater the opportunity for medical discoveries, economic development, and adaptive responses to such new challenges as climate change.

Sullivan, Kathryn Demuth. "Ever Wonder Why There Are so Many Hexagons in Nature?" *Ever Wonder Why There Are so Many Hexagons in Nature?* August 13, 2017. Accessed July 12, 2020. <https://www.labroots.com/trending/videos/10939/ever-wonder-why-there-are-so-many-hexagons-in-nature#:~:text=Hexagons, in particular, are often,but definitely not the only.&text=A hexagon is the shape,of its 120-degree angles>.

A hexagon is the shape that best fills a plane with equal size units and leaves no wasted space.

Warren, Mobi. *The Bee Maker*. San Antonio, TX: Mobi Warren, 2019.

In the year of 2036, honeybees are nearly extinct and the world's crops are disappearing. Melissa's origami honeybees may be the key to saving them. Set in the present and the past, on a small island off the coast of Crete and in Texas Hill Country, this YA novel shows that young people can overcome adversity by realizing the strength within themselves.

Weaver, Maggie. "#FeedABee Initiative in Allegheny County Gives Bee Colonies Plants and Land to Stay Fed." *Pittsburgh City Paper*. Accessed July 15, 2020.

In 2017, the Feed a Bee initiative set a goal to fund pollinator-dedicated gardens and farms in all 50 states. And with help from local organization Allegheny County Conservation District (ACCD), Feed a Bee reached this milestone. March 20, 2019.

<https://www.pghcitypaper.com/pittsburgh/feedabee-initiative-in-allegheny-county-gives-bee-colonies-plants-and-land-to-stay-fed/Content?oid=14209867>.

On its website, Feed a Bee notes, "Bees need to visit about two million flowers to produce one pound of honey."

What's Happening to The Bees? Why Are They Important. Directed by Ignasi Bartomeus. Performed by Ignasi (Nacho) Bartomeus. *What's Happening to the Bees?* April 08, 2016. Accessed July 12, 2020.

<https://www.youtube.com/watch?v=pnY9R-feIDA>.

there are twice as many bee species as bird species

"Why Conserve Pollinators." A Decline That Is Simply Unsustainable. Accessed July 15, 2020. beecityusa.org/why-conserve-pollinators.html.

1 in every 3 bites of food we eat is courtesy of insect pollination. Equally important, 90% of all wild plants and trees rely on pollinators for the survival of their species. Today, it is generally believed that honey bee decline is caused by a complex combination of factors that progressively weaken their individual and collective immune systems, including diseases, parasites, monocropping, and exposure to insecticides, fungicides and herbicides—including some systemic pesticides that permeate the entire plant being treated.

Why Do Bees Build Hexagons? Honeycomb Conjecture Explained by Thomas Hales. Directed by Joe Double and Tom Crawford. Performed by Thomas Hales. Tom Rocks Math. January 16, 2019. <https://www.youtube.com/watch?v=7edkFs8Vu1E>.

Why Do Bees Love Hexagons? Directed by Zack Patterson and Andy Peterson. June 10, 2014. <https://www.youtube.com/watch?v=QEzlsjAqADA>.

Why Nature Loves Hexagons. Directed by Andrew Matthews. Performed by Joe Hanson. It's Ok to Be Smart. August 03, 2017. Accessed July 12, 2020. https://www.youtube.com/watch?v=Pypd_yKGYpA.

tile a plane with cells of equal size, no wasted area...honeybees make round wax cells, as the wax is softened by heat from the busy bees it's pulled by surface tension into stable hexagonal shapes

Writer, Staff. "Bees, Ants, Wasps and Similar Insects of Pennsylvania." Bees, Ants, Wasps and Similar Insects of Pennsylvania. July 22, 2019. Accessed July 12, 2020. [https://www.insectidentification.org/insects-by-type-and-region.asp?thisState=Pennsylvania&thisType=Bee, Ant, Wasp and Similar](https://www.insectidentification.org/insects-by-type-and-region.asp?thisState=Pennsylvania&thisType=Bee,Ant,Wasp%20and%20Similar).

general characteristics, taxonomic hierarchy, identifying information, relative size comparison, territorial reach/map, anatomy

Visible Thinking Routines

Guidelines: These activities can be done after a reading is completed or as the beginning of a lesson. It is a good way to stimulate conversation but to also check for understanding.

1. See-Think-Wonder: A routine that stimulates curiosity and inquiry careful observations.
2. Tug of War: Students reason carefully about the 'pull' of various factors gain a deeper appreciation of the complex forces that 'tug' at either side of a fairness dilemma.
3. I used to think now I think... : Used to help learners reflect on how their thinking has shifted and

changed over time.

4. Claim, Support, Question: Can be used with text or as a basis structure for mathematical and scientific thinking.

Student Reading and Viewing List for Discussion and Debate

The reading and viewing list represent a sample of web-based articles and videos that can be assigned for students to read and view as they prepare for a discussion or debate. The list includes readings at various reading levels. Scaffolding of the more difficult readings is recommended.

Ted Talk videos, articles, and a book

1. "Why bees are disappearing" by Marla Spivak, TEDGlobal 2013. Available at: ted.com/talks/marla_spivak_why_bees_are_disappearing/discussion
2. "Every city needs health honeybees" by Noah Wilson-Rich, TEDxBoston 2012. Available at: ted.com/talks/noah_wilson_rich_every_city_needs_healthy_bees
3. "The hidden beauty of pollination" by Louie Schwartzberg, TED 2011. Available at: ted.com/talks/louie_schwartzberg_the_hidden_beauty_of_pollination?referrer-why_we_need_bees
4. "A plea for bees" by Dennis vanEngelsdorp, Taste3 2008. Available at: ted.com/talks/dennis_vanengelsdorp_a_plea_for_bees_healthy_bees?referrer-why_we_need_bees
5. "The first 21 days of a bee's life" by Anand Varma, TED 2015. Available at: ted.com/talks/anand_varma_the_first_21_days_of_a_bee_s_life?referrer-why_we_need_bees
6. "Loss of bees causes shortage of key food crops, study finds" by Oliver Milman, The Guardian. Available at: theguardian.com/environment/2020/jul/29/bees-food-crops-shortage-study
7. "The Bee Maker" by Mobi Warren, 2019

Appendix on Implementing District Standards

PA Core Standards for Mathematics includes practice standards that grow in complexity as students' progress in their education. The practices reflect what skills students should develop within the scope the course's content. This unit will focus on five of the practice standards. All standards are available through the PA Core Standards for Mathematics website.

CC.2.3.HS.A.4 Using various methods, write formal proofs and/or use logic statements to construct or validate arguments.

CC.2.3.HS.A.8 Use and/or develop procedures to determine, describe, or estimate measures of perimeter, circumference, area, surface area, and/or volume.

CC.2.3.HS.A.9 Describe how a change in the linear dimension can affect perimeter, circumference, area, surface area, and/or volume.

CC.2.3.HS.A.11 Use coordinate geometry to establish properties of two dimensional shapes.

CC.2.3.HS.A.14 Apply geometric concepts in modeling situations.

Standards for Mathematical Practice (MP) includes eight practice standards that grow in complexity as students' progress in their education. The practices reflect what skills students should develop within the scope the course's content. This unit will focus on three of the eight practice standards. All standards are available through the Common Core website.

1. MP1: Make sense of problems and persevere in solving them.

Mathematically proficient students start by explaining to themselves the meaning of a problem and looking for entry points to its solution. They analyze givens, constraints, relationships, and goals. They make conjectures about the form and meaning of the solution and plan a solution pathway rather than simply jumping into a solution attempt.

2. MP3: Construct viable arguments and critique the reasoning of others.

Mathematically proficient students understand and use stated assumptions, definitions, and previously established results in constructing arguments. They make conjectures and build a logical progression of statements to explore the truth of their conjectures. They justify their conclusions, communicate them to others, and respond to the arguments of others.

3. MP4: Model with mathematics.

Mathematically proficient students can apply the mathematics they know to solve problems arising in everyday life, society, and the workplace. A student might use geometry to solve a design problem or use a function to describe how one quantity of interest depends on another. They are able to identify important quantities in a practical situation and map their relationships using such tools as diagrams, two-way tables, graphs, flowcharts and formulas.

Next Generation Science Standards (NGSS) includes eight science and engineering practice standards that grow in complexity as students' progress in their in education. The practices reflect what skills students should develop within the scope the course's content. This unit will focus on three of the eight practice standards. All standards are available through the NGSS website.

1. Practice 1: Asking Questions and Defining Problems

The standards state that by grades 9-12 students are able to ask questions and define problems in 9-12 that builds on K-8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.

In this unit, students are asked to observe a global problem, air pollution and health, and are expected to seek additional informational from their observations. Furthermore, they are encouraged to interpret data, challenge available information in order to deepen their own understanding.

2. Practice 7: Engaging in argument from evidence

Practice 7 in 9-12 builds on K-8 experiences and progresses to using appropriate and sufficient evidence and

scientific reasoning to defend and critique claims and explanations about the natural and designed world(s).

Arguments may also come from current scientific or historical episodes in science.

In reading and comparing the available literature on e-cigarette use and its relation to respiratory health students will compare and evaluate arguments for or against the use of electronic cigarette for tobacco cessation. In addition, students will evaluate claims, evidence, reasoning from multiple sources while practicing critical reading strategies. During the class discussions and debate they must be able to construct a defense statement for their arguments and provide support for their claims from non-fiction sources.

3. Practice 8: Obtaining, evaluating, and communicating information

Practice 8 in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.

Similar to Practice 7, this unit allows students the opportunity to critically read scientific literature to determine central ideas and to summarize complex ideas from technical text. Through scaffolding, students will be able to compare multiple sources regarding respiratory health and air pollution and credit the validity of the source by examining the accuracy of the claims in the articles and or videos. The final project allows students to communicate their understanding and level of knowledge regarding the scientific information they have gathered.

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