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STEAM and Human Centered Design of Biotechnology

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“Every child is an artist. The problem is how to remain an artist once we grow up.”

-Pablo Picasso[1]

[image omitted]

Figure 1 Picasso’s collage of the Three Musicians.

Introduction

The driving question for this curriculum is: How can we increase the overall adoption of biotechnology that is affordable, accessible, and appropriate to improve the human condition? Students will discuss the importance of human centered design of biotechnology and will learn about the various arguments that people make in favor of affordability, accessibility and appropriateness for ethnically, religiously and socioeconomically diverse communities in the U.S. and abroad. A great entry event is to view and discuss MIT Professor Hugh Herr’s Ted Talks on bionics. The project workflow will have students view photos of biotechnology on the web and discuss the reasons why this technology exists and why it is important. As a Geometry class students will use colorful gumdrop candies (or marshmallows) and toothpicks [text omitted]. They will also discuss the fundamentals of bioengineering to design inexpensive prosthetic devices to improve the lives of people in rural countries. By integrating the arts into the teaching of STEM subjects, it is clear that STEM subjects become increasingly accessible and appealing to more people. Studying art contributes to the development of essential skills like collaboration, communication, problem-solving, and critical thinking.[2]   Additionally, this unit will focus of problem solving. The students, like doctors and engineers, will practice thinking creatively and critically to solve problems that relate to the world around them and other fields of mathematics and science. This unit will provide the students with a deeper understanding of careers in science, technology, engineering, art, and mathematics and spark their interest in pursuing STEAM based careers. Suggested student assessment would be to have each group choose one of its ideas and write a plan for how the class could carry the idea out. It must consist of an explanation as to, why the plan is a good one and what it will accomplish, a list of the ailments that will benefit from the plan, and a description of the difficulties that might be associated with this plan.

Rationale and School Profile

The classroom is one of the few environments where social justice and equity can exist. As an inner city, Pittsburgh public school educator I am morally obligated to advocate for the students who are underserved. At Brashear High School, 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 reimagining 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 can achieve through inquiry-based learning or learning by doing. The STEAM movement has been around for about 16 years. The arts may seem like an unacceptable or illogical addition to the sensible grouping of Science, Technology, Engineering, and Mathematics but the point of STEAM is to suggest that teaching the sciences in a way that integrates the arts is more beneficial to students. Creative activities can relieve stress, aid communication, and help arrest cognitive decline.[3] After a crazy and tumultuous year, we all could use some art therapy.

Content Objectives

The students that will be enrolled in my Geometry classes for the 2021-2022 academic year will be mostly sophomores whom I've had the honor of teaching as freshman. As freshman at Brashear High School, they have successfully passed Biology. As sophomores, they will be enrolled in Chemistry. The content background may be a refresher for the most part: What is biotechnology? How can we understand biotechnology, the status of global biotechnology, and its importance? What are the concrete threats to biotechnology? Is it possible to maintain biotechnological affordability, accessibility, and appropriateness to improve the human condition? One of the things I love most about being a teacher is that each day I get to see the direct impact of the work I do. I imagine that biotech engineers feel the same gratification, from their resulting research and development that I feel from my students. Teachers, like biotech engineers, must often attend to urgent matters. Over the past fifteen years, I have seen just how high the stakes are for my students. Every skill or life-lesson I teach them can open the door for opportunities and put them on a different life path. Similarly, advancements in biotechnology, like prosthetics, are enhancing the capabilities and quality of life of individuals with physical impairments. By creating a curriculum unit focused on engineering in biology with a geometrical lens will allow me to enlighten the mind of my students, while sharing ways biotech engineers are changing the lives of everyday people. This unit will foster transformational change by influencing all areas of the students' lives, from academic growth to problem solving and career development. Academically, the students will gain exposure to real world scientific connections.

At Brashear High School, we believe that part of the 21st century of competencies are Accountability, Advocacy, and Awareness. These three competencies have their foundation in the core beliefs of Empathy, Equity and Efficacy. [text omitted] responsibility for their work and actions through Advocacy by participating as active and compassionate members of our school community while using their voices and actions to relentlessly demand equity for and integrity from our community, our peers, and ourselves. Accountability measures include holding everyone in our community to the highest possible standard and expect each other to do the right thing granted that we require ourselves and others to be fully engaged in learning. Ultimately, through Accountability, students will commit to demonstrating situational awareness and empathy by acknowledging the boundaries and individuality of one another.

[text omitted] the fields of geometry, biology, and technology. With the advancement of technology and the advancement of medicine, these fields are growing and weaving together. Currently, the global pandemic has necessitated needs in the medical field, which in turn [text omitted] showcases how science and technology overlap and support each other. This will also show possible career paths in these fields. This unit will be a total of ten 45-minute periods (with-in an alternating 90-minute block schedule) introduced at the start of the second semester. There will be several topics that will be covered with accompanying activities and projects. [text omitted] and gain an appreciation for the importance of human centered design of biotechnology and will have learned about the various arguments that people make in favor of affordability, accessibility and appropriateness for ethnically, religiously and socioeconomically diverse communities in the U.S. and abroad.

Background Content

What is biotechnology?

It is paramount that we teach students to make connections between what they see in everyday life from social media to the front-page news and what they learn in the classroom. The current group of students may be given more social and physical power than any group of students before them.[4]   We may choose to teach the curriculum lacking social context, trusting that the students will make these connections through self-discovery. But students imitate our behaviors and follow our lead. We must combine social issues into the curriculum by modeling social responsibility and demonstrating the need in making sense of the relationship between biological sciences and engineering technologies.

Relating biology to technology together has been around for the best part of six thousand years. The term "biotechnology" was first coined in 1919 and a UN convention of biodiversity interpreted the definition as "any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processed for specific use.[5]   Some major applications of biotechnology include genetic modifications in agriculture, hydroponics, animal sciences, bioengineering with food technology, biomimicry or manufacturing of sustainable materials that mimic biological systems, and biomedical technology in the development and growth of disease detection and diagnosis.

[image omitted]

Figure 2 Design thinking is a social technology that blends practical tools with insights into human nature.

Advantages of biotechnology

It is unmistakable that biotechnology will have an influence on everyone's life as we approach the 21st century. Students cannot turn on a television without hearing about the impact it is having on society. From manufacturing electric vehicles to lower greenhouse gas emissions to combat climate change to reducing infectious disease rates through novel genetic approaches. In order to make moral and intelligent choices regarding their daily decisions, students will need to have a basic understanding of biotechnology. Biotechnology has been around for some time. One of the oldest forms of biotechnology that exist today is wine making which includes the microorganisms used for fermentation. Beer is made using engineered strains of brewer's yeast.[6] Some other notable advantages of biotechnology include improved health through reduction of hunger by improving nutritional content of our food supply. Biotechnology improves nutritional density and cropland yields so people can still receive the same nutritional values while eating less.[7] This advantage allows for flexibility within the food chain by creating crops that are naturally resistant to pests. This unit will primarily focus on the medical advancement opportunities offered through prosthetic technology, bionics, and applications of DNA origami.

[text omitted] The earliest example of a prosthesis ever discovered is a big toe that belonged to an Egyptian noblewoman. In order to wear the traditional Egyptian sandals, the big toe was exceptionally important.[8] Prosthetics have advanced tremendously in the last few decades. From armored knights of the dark ages relying on iron prosthetics for hiding lost limbs to the wooden peg legs and metal hooks attributed to seafaring pirates, the students will investigate as a team about biomedical engineering and the technology of prosthetics. Prosthetics [text omitted] or pick up specific items.

Each and everyday people encounter disease, injury, or trauma that repair and regenerate body parts. These body parts can range from cells within one chamber of the heart to an entire limb like the leg or a hand. Doctors and biomedical engineers use a variety of techniques and technology to help their patients maintain the highest quality of life possible. Orthotic or prosthetic technology is a field in which artificial tissues, organs, or organ components are used to replace damaged or completely absent parts of the body.[9] While many prosthetics are found outside the body, another job of biomedical engineers is to test and develop new materials that can safely be implanted onto the body.

Prosthetics

After studying the history of prosthetics, student teams create prosthetic prototypes using various ordinary materials. Each team will demonstrate their device's strength and consider its pros and cons, giving insight into the characteristics and materials biomedical engineers consider in designing artificial limbs. Two activities that will be incorporated here to spark creativity and innovation are The Alternative Limb Project and the Drinking Straw Robot Hand.

Each year, more than one million people undergo an amputation, which breaks down to one in every 30 seconds. New patients were often fitted with prosthetics that may not have been in sync with how they performed with their amputated before the surgery. "Not many researchers have taken a geometric approach to measuring the economy of how people move their bodies from one step to the next."[10]   Bioengineers are now measuring how people interact with their physical environment to quantify what that person is doing. Applying both external geometric assessments, such as water immersion and circumferential measurements, and internal geometric assessments, such as the 3D volumetric imaging that is ultrasound, bioengineers can design a better prosthetic that relies on the observations, skills, and experiences of the individual prosthetists.

Biomedical engineers apply techniques using their understanding of body systems to develop devices and technologies to meet the needs of humans. When an entire arm, leg, or hip needs to be replaced doctors often look to prosthetics. Prosthetics are designed to look as much as possible like the original body part and must be made with characteristics of durability, comfort, strength, and longevity. Common prosthetic procedures include surgery of the joints at the knees and hips. Several different materials are currently used for prosthetics such as laminated fibers, willow wood, plastics, carbon-fiber composites, and metallic alloys.[11] The main concern with new materials is how long they will last. Presently, hip and knee prosthetics last anywhere from ten to fifteen years. This is not favorable for young patients and researchers are looking to add things to prosthetics to help promote bone growth. In addition to the materials used, biomedical engineers also focus on the joint, connections, and sensors that the prosthesis has to the body. New technology is being developed to use small sensors, implanted in the body, that detect minute electoral changes in nearby muscles and nerves. This data is then transmitted to the prosthesis and movement is produced. This new wave of sensors is more lifelike and offers the widest range of movement for the patient.

[image omitted]

Figure 3 The Vitruvian Man is part work of art and part mathematical diagram, conveying that everything connects to everything else.

History of Bionics

There is a long history of amputations and, consequently, prostheses as their most instantaneous solution starting with hooks and other prosthetic replacement of the Middle Ages. Continuing to Ambroise Pare's mechanical hand to modern robotic and bionic limbs which are the results of both technological and medical progress. Contemporary prosthesis development was enhanced because of the World Wars. First in Germany and then in the former USSR.[12]   The prehistory of amputations, prosthetics, and bionics dates to when the pharaohs began ruling Egypt in 3000 BC. A wooden toe that was fitted to the foot of the remains of a woman, believed to be the daughter of a high status ancient Egyptian priest, with a piece of leather is the first known prosthesis used. "The technical know-how can be seen particularly well in the mobility of the prosthetic extension and the robust structure of the belt strap. The fact that the prosthesis was made in such a laborious and meticulous manner indicates that the owner valued a natural look, aesthetics and wearing comfort and that she was able to count on highly qualified specialists to provide this."[13]   Centuries passed until mechanical limbs began being used that recovered the function of the lost appendages. It was in the sixteenth century when Ambroise Pare, a French barber and surgeon, invented a prosthetic hand with a mechanism that allowed for moving fingers. Pare's work in the battlefield laid the foundation for surgical amputations, and essential step that led to making implants. The technology of artificial limbs has been closely linked to battle with significant progress occurring after each of the major wars which prompted the development of modern prostheses made of new materials such as plastics and titanium.[14]

Bionics

One of the great achievements of bionics was in 1976 and the introduction of cochlear implants. For the first time it allowed a person to regain a sense of hearing. In contrast to a hearing aid, which amplifies sound, cochlear implants allowed patients whose auditory nerve works perfectly with keen deafness, due to damage to the cochlea located in the inner ear, to feel the sound.[15] In 1982 another major conception of bionics was to replace the human heart with an artificial device. The basic mechanics of the artificial heart is a pump system, but the subtleties of the most important muscle meant the imitating it in a permanent way continue to be an ongoing challenge.[16] The 1960s saw the inauguration of modern robotics thanks to the work of institutions like MIT and its Artificial Intelligence Laboratory. Heinrich Ernst, in 1961, developed the first computer operated mechanical hand. Researchers at a hospital in Downey, California in 1963 created the first robotic arm designed to aid patients with disabilities.

Advances in human bionics may require us to rethink our concepts of what it is to be human.[17] Bionics is the study of mechanical systems that functions like living organisms or parts of living organisms. The idea of using technology to build faster, stronger, and more powerful bodies have captivated the human imagination from the bumbling Inspector Gadget to the indestructible Terminator. Bionic limbs are more lifelike and constantly evolving in their form and function. There are many different types of bionic limb technology available, but the development of bionic limbs does have a long way to go before they can achieve the full range of control, motion and sensitivity of biological limbs.

History of Origami

Numerous studies argue that origami was invented by the Japanese about a thousand years ago, but its roots may well be in China because the first papermaking process was documented during the Eastern Han period. Chinese papermaking spread to the Islamic world during the 8th century where pulp and paper mills were used for papermaking and money making.[18] It is also likely that the process of folding was applied to other materials before paper was invented so the origins of recreational folding may lie with leather or cloth. The practice of napkin folding, and cloth pleating were certainly held in high esteem within Europe. Nevertheless, paper has proved to be the ideal material to fold and so it is logical to assume that paper folding followed the discovery of the papermaking process.[19] Earliest records indicate that origami was primarily used for ceremonial or religious reasons. Ultimately, as people became more interested in it, origami was used for artistic and decorative purposes. It is also used as a tool to teach basic principles of math and geometry.[20] Principles of origami are now used in a broad variety of applications. Applying origami principles help fit large objects into a smaller shape – from the design of self-assembling robots to heart stents, to satellites – after which they can expand again.[21]

DNA Origami

DNA is a nucleic acid that contains the genetic instructions for the development and function of living things. Origami is the art of paper folding. DNA origami is the art of folding DNA. We summarize the methodologies of DNA origami technology, including origami design, synthesis, functionalization and characterization. We highlight applications of origami structures in nanofabrication, nano photonics and nanoelectronics, catalysis, computation, molecular machines, bioimaging, drug delivery and biophysics. (DNA and DNA Origami Lesson)[22] Students will be introduced to the idea that bioengineers can create tiny nanoscale machines that might possibly work inside the human body. Since the technique was first reported ten years ago, the field of

DNA origami has grown tremendously. The students will be introduced to Paul Rothemund's research on how DNA origami works and what has been achieved so far through YouTube videos.[23]

Disadvantages of biotechnology

Biotechnology does offer the world the potential of boundless advantages, but it also has its disadvantages and areas of concerns. For instance, genetic modifications in agriculture allow pathogens to create resistance to herbicides and there are unknown potential health effects on humans from foods products created through cloning. Additionally, the initial setup of a hydroponic system is expensive, and the creation of organic foods may lead to allergic reactions. Manufacturing something that mimics nature does not fundamentally make it environmentally friendly. Furthermore, hazards from software problems in biomedical technology may come to light and DNA fingerprinting privacy issues becomes a paramount concern when hacking is becoming more and more prevalent. Students will research how knowledge can easily be abused and how unintended consequences may arise from developing new technology.

Moral and ethical issues

We live at a time of escalating technological ability. Ethics compels all of us to meaningfully engage with technology and science to create a just world in which all can thrive. Our ethical considerations include a variety of stakeholders, so it is important that the general public, as well as student scientists, engage in discussion about ethical and moral issues. Ethics gives non-scientists a reason to care about complex scientific advances, and it gives scientists a reason to engage in the public square.[24]

Case studies will provide the students with a more relevant and deeper understanding of a complex research problem. Students will examine three ethical issues involving conducting clinical trials in developing countries, the elimination of native populations of disease carrying pests through genetic manipulation, and questions of coercion in the field of organ donations.

STEM vs STEAM

Art has a prodigious impact on society and culture around the world.[25] Imagine a world without any film, literature, music, dance, or any of the innumerable other mediums that art exists through. After six years I sometimes get the side-eye when I mention that Brashear High School has a STEAM academy versus a STEM academy. The importance of art is disregarded, taken for granted, and questioned. An integral part of STEM is the "A." Studying art contributes to the development of essential skills like communication, collaboration, critical thinking, and problem.[26] A University of Florida study found that "on average, students who study the arts for 4 years in high school score 98 points higher on the SATs compared to those who study the same for half a year or less."[27] The conclusion went further and stated that "students who took up music appreciation scored 61 points higher on the verbal section and 42 points higher on the math section."[28] Integrating the arts is a no brainer for the proponents of STEAM. First and foremost, you can't build eye popping architecture or make a jaw dropping sculpture without engineering, mathematics, and art. Case in point, automobiles are judged not only by engineering features and technology that they possess but furthermore by their aesthetic and design qualities. Critics have expressed concern that concentration in the arts may take away valuable time from STEM investigations. Among the main concerns is that adding arts to STEM programs will weaken the study of these much-needed fields. While science, technology, engineering, and mathematics have organically been linked for some time, STEAM was not [text omitted] 2005 that STEAM got its own caucus in congress and really gained momentum. [text omitted] of creativity and ingenuity because engineers have regularly integrated design into their work. However, the STEAM maker movement has worked towards sparking students' creativity and innovation through art. Students can use both sides of their brain, creative and analytical, to become better thinkers. The application of art to science, technology, engineering, and mathematics in the classroom is only the first step.

Strategies

The unit will include direct instruction, various artistic mediums, student readings, research projects, project-based learning, virtual field trips and videos, and self-directed and self-chosen learning materials including independent work. This independent work consists of concrete materials that were specifically designed for this topic. Student engagement will be at the forefront of every activity. This will be accomplished through visual thinking routine principles. They include fostering students' natural desire to learn, using their surroundings and the prepared environment to help educate, and encouraging students to be independent thinkers and learners. By allowing students to demonstrate their knowledge in a variety of ways gives them more ownership over their education and their chosen topic of interest.

If you are still unconvinced that art can be applied to cutting edge technology and science, [text omitted].[29] [text omitted] two-dimensional crease patterns to create any three dimensional object from a piece of paper. Neither of them is an artist. [text omitted] Erik Demaine is a mathematician at MIT. [text omitted][30]   [text omitted] three-dimensional tools. The list goes on, even within [text omitted] the STEAM programs have not already found success. [text omitted] [31]   One this that both sides can agree on in the STEM vs. STEAM debate is that art has naturally [text omitted].

This unit curriculum is also based on the teaching practice of Gameful thinking. [text omitted] to the assignment as they would [text omitted]. At the start, to pass the activity or project each student need to receive a certain number of points. Different letter grades can represent different value of points; for example, an A letter grade could equal 200 points, an B letter grade could equal 160 points, etc. Different activities and projects can be a certain amount of points and students can choose what they will complete in order to collect [text omitted] steps and students receive points for each step completed. Like YNI's guidelines for writing a curriculum unit, the activities or projects in this unit will be presented and formatted as such. [text omitted] creatively [text omitted] activity or project [text omitted] students to redraft their work until the due date and make modifications as needed to improve their design gives them confidence and skills to solve real world and working condition problems. The students will use the design thinking process throughout the activities and projects.

Concepts of Design Thinking: Empathy, Define, Ideate, Prototype, Test

We will model the five stages of the Design Thinking process shared by Professor Anjelica Gonzalez. Empathy will permit the students to set aside their own assumptions and stereotypes about the world in order to gain an appreciation into other people's feelings. In my attempt to teach empathy, I will show a lovingly crafted short animation called "The Present" where a mother brings home a puppy as a present for her young son, but he dismisses the puppy because it has a disability. Feeling supported and understood is extremely important for students to increase self-awareness and helps them stay motivated while encouraging them to advocate for themselves.[32]   Once the viewing of "The Present" is done, the students will be individually tasked with researching the history of prosthetics and then they will meet in their groups and share their findings. They will answer the following questions in their research: What are some significant achievements in the field of prosthetics? [text omitted] What materials have been used?

Defining an actionable and meaningful problem statement (How might we help ___________ to ___________.) will allow the student to narrow their focus on solving the issue. This might be the most challenging stage of the design thinking process because it will need the students to unify their observations about the users from the first stage of empathy. One method of interpreting findings and results from the empathize phase include one of my favorite visible thinking routines “Think-Pair-Share.” [text omitted] both the young boy and the puppy from “The Present.” [text omitted] an adolescent boy of 12 years in middle school and a Pitbull puppy. This will allow students to research the traits that the young boy and the puppy must better suit their design.

During the third stage, students will start to identify new solutions to the problem statement they created and start to look for different ways of viewing the problem by thinking outside the box. One method to spark the creativity and innovation is storyboarding. Aside from aiding with team collaboration, storyboarding helps the students visualize their learning design through a graphic narrative where they tell a story, explain the process, and show the passage of time. Similar to this summer’s crash course in design thinking where the fellows were asked to bring simple items such as paper clips, paper, tape, markers, etc. to our first session with Professor Anjelica Gonzalez, the students will carry out some form of prototyping. This method involves the students brainstorming to produce a scaled down and inexpensive product that will help the user with their issue. [text omitted] a young boy moves and lives while also thinking [text omitted]. This fourth stage will allow the students to bring their ideas to life and empower their peers to investigate how they think and feel about the product. The students will think about material, shape, how it will be made, how it will work, and the estimated cost of the prosthetic.

Testing can be used concurrently with the prototyping stage of design thinking. A visible thinking routine method that can be utilized in this stage is role playing. The students will try to get their peers to be users and perform a task when testing the prototype. The key is to get the user students to use the prototype as they would in real life as much as possible for meaningful feedback. The beauty of the design thinking process is that testing can be tackled throughout the progress of a design thinking project. Students will follow the design thinking process and make a prototype out of any inexpensive material they can get their hands on. Materials that will be provided, but are not limited to, are [text omitted], Google Slides, [text omitted] implementation of the design thinking process, and explain how they came up with their design.

[image omitted]

Figure 4 DNA Art is at the cutting edge of science and art.

Classroom Activities

Activity One – Math Journaling/Thinkmarks

Research suggests that a student’s math competency is directly related to their mother’s reading skills.[33] The goal of this exercise is to develop students’ reading skills and (more importantly) listening skills. Often, students see math as a subject of numbers, not a subject of discussion and rich communication. Getting started is the most challenging aspect of utilizing math journals. First, start with something simple. Begin with a three-minute task where students write and draw about how they feel about math (Is math your favorite subject? Why or why not? What do you like most about math? What do you like the least about math?). Secondly, to help students gain a better idea of quality work and self-improve, present a math journal rubric to help make scoring more accurate, consistent, and unbiased.

For example:

	MATH JOURNAL RUBRIC
4 Advanced	☐ I answered the questions correctly, using appropriate math language.
	☐ I fully used pictures, drawings, charts, numbers or words to explain my thinking.
3 Proficient	☐ I answered some of the questions correctly, using appropriate math language.
	☐ I have used some pictures, drawings, charts, numbers or words to explain my thinking.
2 Basic	☐ I answered the questions with appropriate math language, but my answer may not be fully correct.
	☐ I may have used some pictures, drawings, charts, numbers or words to explain my thinking.
1 Below Basic	☐ I did not answer the questions, or I did not answer it correctly.
	☐ I have no pictures, drawings, charts, numbers or words to explain my thinking.

Read through the responses and choose a few examples of quality work to evaluate anonymously in front of the class. You may even ask for volunteers to share theirs and read aloud. I've had the entire class volunteer to have their work critiqued because they found the feedback to be so helpful. There's an inspiring YouTube video that encompasses the value of peer critique and peer feedback through the eyes of a first grader named Austin.[34] This six-minute video, which should be shared with the class, is narrated by Ron Berger and tells the story of Austin's butterfly. "*The Story of Austin's Butterfly*" exemplifies the transformational power of critique, descriptive feedback, and models to improve student work. Thirdly, and most importantly, make journaling a regular activity. Include the journaling experience during each unit. You may even consider increasing the three-minute timer to four-minutes, then to five-minutes, etc. Typically, I like to assign the writing/drawing task during the "Engage" portion of the five E's (Engage, Explore, Explain, Elaborate, Evaluate). The beauty of this activity is that it can be implemented in any part of your daily lesson plan.

Activity Two - 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: creating mandalas, viewing MC Escher drawings, building a gumdrop geodesic dome, discovering the golden ratio, applying the theory of proportions, and boost mindfulness through origami. Origami is good for the students as it develops their eye hand co-ordination, sequencing skills, math reasoning, spatial skills, memory, but also patience and attention skills. First, start with something simple. Start with a rectangular piece of (lined) paper and search for the instructions for making a paper airplane. Have the students use colored pencils or markers to decorate their paper airplane. Fly their airplane! Find an area clear of people and other hazards and gently have them toss their design. The students should measure and record the distance of its flight, as well as use a stopwatch to measure how long their airplane stays in the air. At this point, the students (preferably in groups) will adjust their design and try again. Spark a lively discussion about how airplanes fly. What part of an airplane helps it fly? Then use the following questions to discuss how systems and structures often mimic nature [text omitted] Secondly, like the first activity, to help students gain a better idea of quality work and self-improve, present a rubric to help make scoring more accurate, consistent, and unbiased. Thirdly, progress the student's paper folding skills to create geometric objects that mimic nature. "*Looking for More Multi-Sensory Play Ideas? 25 Easy Origami Figures for Kids to Create!*" will enhance their understanding of two-dimensional polygons as well as their problem-solving skills to create three-dimensional shapes from a flat two-dimensional surface.[35]

Activity Three – Drinking Straw Robot Hand/Alternative Limb Project

In this activity, students will learn how to use a glue, drinking straws, and sewing thread to engineer a surprisingly lifelike and useful robot hand. They are to design and build a working hand out of craft materials that exhibits how real robotic hand might work. What will they design to have their robot hand do? Pick up a ping pong ball? Move around a can? It will ultimately be up to them! First, with guidance and starting instructions (https://www.kaplanco.com/ii/diy-robot-hand), the students will design any type of hand that will simulate human finger anatomy as the basis for a fully functional hand that is easy to build and does not require intricate tools.[36]   Secondly, like the first activity, to help students gain a better idea of quality work and self-improve, present a rubric to help make scoring more accurate, consistent, and unbiased. Thirdly, at this juncture of the activity, the Alternative Limb project will be introduced. Founded by Sophie de Oliveira Barata, the Alternative Limb project uses the unique medium of prosthetics to create highly dramatic wearable art pieces. Alternative Limbs explore themes of transhumanism, modification, evolution, and body image while encouraging positive conversations around celebrating body diversity and disability.

Activity Four - Culminating Activity: Cool STEAM Careers

The goal of this exercise is to expose the students to opportunities available to them through STEAM careers. The students are knowledgeable about many careers in science and mathematics but often don't gain as much exposure to careers in biotechnology. First, suggested student assessment would be to have each group choose a career in biotechnology and write a plan for how the class could carry the journey of becoming a biotech engineer out. There are many jobs involving biotechnology and new careers are being developed every day. [text omitted] education or training, the students must include at least two schools/training facilities from which one could obtain the degree. Secondly, like the first activity, to help students gain a better idea of quality work and self-improve, present a rubric to help make scoring more accurate, consistent, and unbiased. It must consist of an explanation of why the plan is a good one and what it will accomplish, a list of the benefits from the plan, and a description of the difficulties that might be associated with this plan. Thirdly, once students are done with this assignment, the class will gather as a group [text omitted] career opportunities.

Visible Thinking Routines

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

See-Think-Wonder: A routine that stimulates curiosity and inquiry of careful observations.

Tug of War: Students reason carefully about the 'pull' of various factors to gain a deeper appreciation of the complex forces that ‘tug’ at either side of a fairness dilemma.

I used to think…now I think…: Used to help learners reflect on how their thinking has shifted and changed over time.

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

Think-Pair-Share: This strategy requires students to think individually about a topic or answer to a question and then share their ideas with another classmate.

Storyboarding: This activity allows the students to communicate ideas through visual stories that showcase how they fit into the users’ lives.

Gallery Walk: This dialogue technique allows students to be actively involved as they walk throughout the classroom. They work together in groups to share ideas and respond offer feedback to meaningful problem-solving situations, documents, questions, texts, or images.

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.

The New Bionics That Let Us Run, Climb, and Dance: TED Talk by Hugh Herr

The Present by Jacob Frey

7 Badass Things That Technology Will Never Make Obsolete by Joe Choi

The Origami Revolution, NOVA & PBS, Episode 5, Season 44

The Art of Design by Tinker Hatfield, Netflix

Ten Years of DNA Origami, YouTube

“This wearable robotic knee brace may put an end to your knee pain” by Lexy Savvides, c|net

Science of Innovation: Origami Structures by Mary Frecker, YouTube

Innovation Happens When Rules Are Broken by John Stossel, Triblive

3D printed, mind-controlled prosthetics are here, YouTube

The Story of Austin’s Butterfly, YouTube

[image omitted]

Figure 5 Without Geometry, life is pointless.

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 can 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 enough 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. Like 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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