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Prototyping Projects: A Hands-On Approach to Understanding Injuries to the Human Body's Largest Organ Through the Design Thinking Process

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Introduction

L.W. Beecher Museum Magnet School is a Pre-Kindergarten through 8th grade school in New Haven, Connecticut. As the 7th and 8th grade science teacher, I am the only science-specific teacher in the building. For this reason, my main focus is ensuring that the culture surrounding science class and my classroom, the "science lab," is exciting and welcoming. My primary goal is for students to see that science is engaging and fun, and that it applies to their everyday life.

7th grade students will participate in this unit during their cells and the human body curriculum in the second marking period, which typically falls from November to January. At this point in the year, most 7th grade students have not been exposed to a science-specific class or to working in a "science lab" every day. Through this unit, students will gain experience working in a lab, and the skills that are built through experimentation and teamwork. Students will go through the engineering design thinking process to create a prototype for a solution to an injury to the skin. The students will begin by learning about healthy, functional skin and then learn about two major injuries to skin: burns and skin cancer. The focus on framing the unit around the engineering design thinking process is to intentionally bring a hands-on, interactive approach to learning. Through this process students will gain access to a real-world experience of prototype design and ideation.

Rationale

The main purpose of writing this curriculum is to engage students at a higher level of problem-solving thinking and ideating for themselves. At the middle school stage of their academic career, many students are often simply asking questions to directly learn the answers, rather than valuing the process of finding the solution. Through this unit, students will become equipped with problem-solving skills that will shape their thinking in and outside of the classroom. This unit is designed with hopes of engaging students in a new way of thinking by pushing creativity, novelty, and inspiring students to think outside the box. Additionally, this unit will serve to teach students to value the process of problem solving to find an answer, rather than simply valuing the right results.

On a personal level, I chose to create a curriculum about the design process due to my own prior experience working in a biomedical engineering lab. During my time as an undergraduate at Cornell University, I spent three years working as an undergraduate researcher studying mouse models of Alzheimer's disease. The experience of hands-on, problem-solving based learning was the most influential learning experience I have had. I loved learning by doing and working through processes to determine solutions. Through this curriculum, I hope to demonstrate to the students that the process is often most important for scientific discovery. Students will learn the skills that I learned through research in the middle school classroom.

Additionally, it is the aim that through this unit students will gain access to understanding what the field of engineering is, and more specifically biomedical engineering, as they work through the design process. Our district has now adopted the Next Generation Science Standards, also known as NGSS. There are three levels of NGSS: Crosscutting Concepts, Science and Engineering Practices, and Disciplinary Core Ideas. The Science and Engineering practices are designed to build skills that all K-12 students should leave the science classroom knowing. These eight skills are: 1. Asking questions (for science) and defining problems (for engineering), 2. Developing and using models, 3. Planning and carrying out investigations, 4. Analyzing and interpreting data, 5. Using mathematics and computational thinking, 6. Constructing explanations (for science) and designing solutions (for engineering), 7. Engaging in argument from evidence, 8. Obtaining, evaluating, and communicating information.

Biomedical Engineering

In the 21st Century Classroom, there has been a growing emphasis on teaching Science, Technology, Engineering, and Math, also known as "STEM." One of these components, Engineering, is the field that focuses on the creation of new technologies and objects, ranging from machines & buildings to skin, using scientific and design principles. Biomedical Engineering, also often referred to as BME, is a subset of Engineering. The focus of Biomedical Engineering is to utilize engineering practices of innovation and design to improve or enhance biology and medicine. Biomedical Engineering is tied closely with the medical field, as BME designs diagnostic therapies and treatments for issues that arise with the human body and creating solutions to gaps in the medical field.

From stethoscopes and scalpels, to doppler ultrasounds and artificial skin, you can thank a Biomedical Engineer for these innovations. As Dr. Street states in Introduction to Biomedical Engineering Technology, "the history of medicine is a story of humans trying to better understand and treat the various diseases and injuries that befell themselves and their companions" (Street, L. 2011). As medicine continues to change and advance, so does Biomedical Engineering, and often these medical advances are directly caused by the new technologies created from BME.

An important aspect of this field is considering the negative and positive implications of these technologies. One example of negative downstream effects of an introduction of technology is the use of ultrasound to change the sex ratio. Ultrasound became a technology that began as a tool for location and navigation inside the body and turned into a way that women could understand and better connect with their future baby while it was still in the womb. Ultrasound ultimately opened the door for identifying the sex of a baby before birth. Unfortunately, when the one child policy was passed in China it became used to determine the sex, and more unfavorable female fetuses were not wanted. Therefore, ultrasound's original creator "could have hardly guessed that ultrasound would one day contribute to a sex ratio imbalance involving over 160 million "missing" females in Asia and elsewhere" (Hvistendahl. 2011.). However, the stronger question, often not asked, is could he have really "hardly guessed" that this would occur? To what extent should or could the original designers and engineers have foreseen ultrasounds possible negative implications as well as its positive ones, and ultimately be held responsible for not only the positive benefits to society but also the negative implications too? The topic of ethics and future planning continue to be debated and the role of responsibility and protection of technologies is spreading far past what it can simply do to benefit society, but also what negative implications may come.

Design Thinking and Process

The Design Process is a series of steps that engineers use to create a new prototype of a technology. Although the Design Process is relatively universally acknowledged, the names for each step can differ slightly depending on the source. For this curriculum, the handbook "Design Thinking for Educators, Second Edition" was used for information regarding the design process, and the following information in this section is from that handbook (Fierst et al. 2011).

There are five phases, or steps, of the process: discovery, interpretation, ideation, experimentation, and evolution. First, in the discovery phase, engineers are challenged to understand their problem fully and prepare research that has already been done to determine how to approach a question or a problem. Next, interpretation is exploring the meaning behind the problem. Also, in this step is the idea of understanding and empathizing with the problem, to better understand how to solve it. The next step is to ideate, to create an refine ideas to determine what to create in the next step. The forth step is to experiment and make prototypes. A large part of this step is also to gain feedback and more knowledge as iterations of the prototype is made. The last and fifth step is evolution, to use what skills and understanding was gained through the past steps to determine how to further improve the prototype and more forward with the technology.

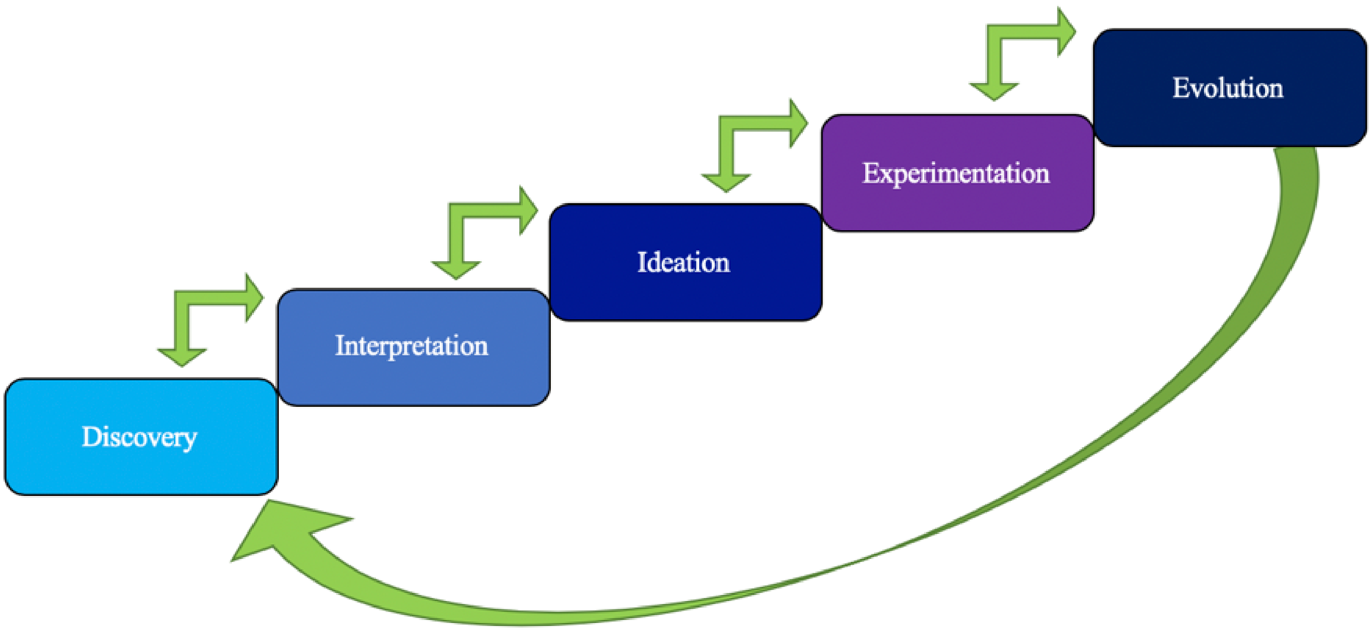

Figure 1. Visual Representation of the Design Process.

Step 1: “Discovery” focuses on creating a whole understanding of the information and ideas provided already. It includes three subsections: understanding the challenge, preparing research, and gathering inspiration. The first of the three, understanding the challenge, involves reviewing the challenge, sharing what you know, building a team, defining an audience and refining a plan. Next, preparing research, consists of identifying sources of inspiration, selecting research participants, building a question guide, and preparing for fieldwork. Last, gather inspiration, requires one to immerse themselves in context, seek inspiration in analogous settings, learn from experts, and learn from users.

Step 2: “Interpretation” focuses on taking the ideas from the previous step and creating a clear direction for action. Like step 1, it also consists of three subsections: tell stories, search for meaning, and framing opportunities. Telling stories means capturing learnings and sharing stories learned throughout the process. Searching for meaning involves finding themes in the research and ideas gained, making sense of the findings, and defining the overall insights form all of the information provided. Last, framing opportunities consists of creating a visual reminder and making insights actionable.

Step 3: “Ideation,” means, “generating lots of ideas…its often the wild ideas that spark visionary thoughts. With careful preparation and a clear set of rules, a brainstorm session can yield hundreds of fresh ideas” (Fierst et al. 2011). This phase consists of two sections: generating ideas and refine ideas. The first, generate ideas, involves preparing and facilitating brainstorming, selecting promising ideas, and sketching to think. The second phase, refine ideas, involves doing a reality check and describing your idea.

Step 4: “Experimentation” relies on creating models and prototypes by using your ideas to create a product. It is made up of two subsections: making a prototype and then getting feedback on the product. Prototyping can involve making a mock up, a model, a diagram, an interaction or a role play. Getting feedback consists of identifying sources for feedback, selecting feedback participants, building a question guide, facilitating feedback conversations, capturing feedback learnings, integrating feedback, and identifying what is needed.

Step 5: “Evolution” revolves around next steps of continuing to grow and synthesize the idea or product. It involves two sub steps, track learnings and move forward. Track learnings is made of defining success and documenting progress, and moving forward involves panning next steps, engaging others, and building a community.

Integumentary System

The skin is the body’s largest organ. The integumentary system consists of the skin and any accessory structures, such as hair follicles, exocrine glands, nails or nerves. There are three main layers of the skin: the top most superficial is the epidermis, the middle is the dermis, and the lowest part is the hypodermis. The epidermis creates a protective, waterproof barrier for human bodies and also is responsible for creating skin tone as melanin-producing melanocytes are located in this layer. The epidermis can also be broken down into five layers (from top to bottom): stratum corneum, stratum lucidum, stratum granulosum, stratum spinosum, and stratum basale. These can be remembered in order via the mnemonic: “come let’s go sun bathe.” The dermis contains hair follicles, sweat glands, and connective tissue. The dermis is made of two layers: the papillary layer and the reticular layer. This is also the outermost layer to be vascularized. The hypodermis is deeper subcutaneous tissue and is made of mostly fat and connective tissue.

The skin’s main function is to protect the body from harm. This includes protection from exposure to bacteria or other harms in the environment, and protection from loss of water and subsequent dehydration. The skin also helps maintain homeostatic temperature through the sweating mechanism. Nerves in the skin detect stimuli in the environment as they sense temperature, pain, and pressure. Therefore, injuries to the skin can often result in imbalances in homeostatic processes and major complications if not addressed quickly. Serious injuries to the skin, such as large or deep burns, can even result in death.

Injuries to the Integumentary System: Skin Cancer

Skin cancer is the most common type of cancer to afflict the human body. The three most common types of skin cancer are basal cell carcinoma (BCC), squamous cell carcinoma (SCC), and melanoma. It is known that UV radiation from the sun can cause these cancers and that UV protective sunscreen can have preventative effects for skin. Although skin cancer is most common on areas of the skin that are regularly exposed to sunlight, skin cancer can also appear on skin not regularly exposed to sunlight radiation.

Squamous cell carcinoma and basal cell carcinoma are both typically treatable often through an outpatient procedure of removing the cancerous skin tissue, while melanoma is much more likely to spread and often requires more intensive treatment including radiation and chemotherapy. However, if detected early enough melanoma can also be cured simply using dermatologic surgery, which is why it is crucial to identify it as early as possible.

Melanoma is most often seen in a mole that has begun to change. The “ABCDE test” can be used to help determine a deleterious change to a mole. A is asymmetry, looking for any un-circular shapes. B is border, looking for any irregularities or patchy borders. C is color, moles should be a consistent color throughout. D is diameter, any mole with a diameter of larger than 6 millimeters or ¼ of an inch is typically seen to be at risk. And E is evolution, if the mole has changed over time. Checking to ensure that any moles do not reach any of the ABCDE criteria is important for ensuring that any possible melanomas are caught early.

Typically, melanoma affects Caucasian individuals more often than people of color. However, “although melanoma occurs less frequently in people with skin of color, the diagnosis is often associated with disproportionately elevated morbidity and mortality in these populations. This poor prognosis is likely multifactorial and due at least in part to atypical clinical presentations of melanoma in skin of color that have the potential to delay diagnosis, often resulting in more advanced disease” (Higgins, et al. 2019). One notable person of color who died of melanoma was Bob Marley, whose cancer started as a darker streak presenting on his toenail.

Injuries to the Integumentary System: Burns

Despite the fact that most of the injuries to the integumentary system are non-life threatening, burns pose a serious issue to this organ. Burns can be caused by a number of things, such as heat, chemicals, radiation, friction, or electricity. Burns traditionally were classified as first-, second-, third- and fourth-degree burns, but are now being classified as superficial, superficial partial-thickness, deep-partial thickness, and full thickness burns as these are better categorized by need for surgery (Chen, Q., & Thouas, G. 2014). The extent of injury of each burn determines its classification. Superficial thickness burns have epidermis damage, partial thickness (superficial) includes damage to the papillary dermis, partial thickness (deep) includes damage to the reticular dermis, and full thickness burns include damage to the dermis and other tissue and can even include damage to muscle or bone.

Existing Solutions: Mohs Micrographic Surgery

Mohs Micrographic Surgery, also known as MMS or simply Mohs, is a dermatologic surgery technique where cancerous skin is removed and checked layer by layer until all of the cancerous tissue is removed. A specifically trained Mohs Surgeon carefully maps out the area of cancerous tissue and will begin by removing a layer and checking the edges under a microscope. They will continue to remove layers until all remaining outer margins are clear of cancerous tissue when investigated under a microscope, which would indicate that they had successfully removed all of the harmful tissue from the body. Following the removal of the cancerous tissue, the surgeon then closes the skin. They can close using a series of flaps or using a graft of skin obtained from another area of the body. The patient is typically awake and locally anesthetized, and the surgery can be completed in as little as one day. Throughout the course of the treatment, the physician acts as pathologist – checking the skins cellular makeup layer by layer, cancer surgeon – detecting and removing the cancer, and reconstructive surgeon – putting the skin back together after removal of all harmful tissue.

Existing Solutions: Tissue Engineering and Tissue Regrowth Aids

There are various solutions that currently exist for aiding when there is significant tissue loss. Tissue engineering is being used to generate new forms of covering that can act as skin. Additionally, skin alternatives, such as using tilapia skin to cover extensive wounds caused by burns (Alves et al., 2018).

Additionally, and there are other therapies that promote of tissue regrowth. For example, the technologies ManukaDress IG and ManukaDress IG Max work to help reduce the issues that arise with damage to the skin due to burns. These products "contain Manuka honey, which has antimicrobial properties and promotes autolytic debridement" (Sack et al., 2018). There has also been success seen with a 3D printed biomask for facial skin. These researchers used three layers of cells: a polyurethane layer, a fibroblast hydrogel, and a keratinocyte hydrogel to help aid in the reduction of scarring, infection, and graft failure (Seol et al., 2018).

Lessons

Prototyping Project

The students will ultimately work through the engineering design project to create a prototype of a possible solution for an injury to the integumentary system. They will work with a partner to increase collaborative learning and will present their prototypes to the class at the end of the unit.

Materials

- Technology (for research, can be computers, Chromebooks, iPads, etc.)
- Paper
- Markers
- Pipe cleaners
- Beads
- Foil
- Felt
- Glue
- Other available materials

Overview of Lessons

This unit will cover the time span of two weeks. The lessons will be as follows:

- An Introduction to Functional Skin (1 day)
- Understanding Injuries to the Integumentary System 2 days)
- Existing Solutions (2 days)
- The Design Process in Action (4 days)
- Prototype Presentations (1 day)

An Introduction to Functional Skin (Day 1)

The beginning of the unit will focus on learning about the basics of the integumentary system, the largest organ of the body. First, students will learn the characteristics of normal functioning human skin. Students will be introduced to the layers of the skin and their functions through the Ted-ED video “The Science of Skin” by Emma Brice (TED-Ed., 2018). Students will then conduct a WebQuest to further learn about the skin. They will be answering questions about skin basics on a worksheet after conducting research on Chromebooks.

Understanding Injuries to the Integumentary System (Day 2 and 3)

On day 2, students will be introduced to two common injuries to the skin – burns and skin cancer. The first to be introduced will be burns. This will hopefully be relatable as students have possibly seen someone with a burn before. Burns will be introduced through the lens of sunburns. Through the video, “What Exactly Does the Sun Do to Your Skin?” students will learn how the sun causes a sunburn (Seeker, 2014). This video will be used to describe the science behind sunburns to engage students in an understanding of how burns can occur every day. This video also leaves room for discussion about skin tone as the video brings it up. Students will then engage in a table discussion about skin tones and racial identity. I will frame this this discussion using my own personal story of my own parents and how that contributes to my skin tone as my mother is from the Philippines and my father is a fourth-generation American with ancestral roots in Sweden and England. It is the intention that teachers can use this opportunity to share more about themselves with their students if they feel comfortable. Following the small group discussion students will have the opportunity to discuss this full class. By having the opportunity to discuss with their classmates and teacher about their similarities and differences, they will gain confidence communicating with those both similar and different from them.

On day 3, after discussing sunburns, skin cancer will be introduced. Students will engage in another WebQuest to work through the three main types of skin cancer - basal cell carcinoma (BCC), squamous cell carcinoma (SCC), and melanoma. Through their own research, they will determine the causes of skin cancer and its effect on the skin. This is intended to be a guided research experience as students will work through a worksheet, knowing exactly what answers they should be finding while they are given the freedom to determine their pathway to finding solutions.

Existing Solutions (Day 4 and 5)

On days 4 and 5, existing solutions to these injuries will be introduced. First, Mohs Micrographic Surgery, will be presented as a solution that has been created to treat certain skin cancer. I will finish the mini section on skin cancer by discussing Bob Marley, who died of Melanoma, demonstrating that melanin levels do not protect against cancers. Providing students with a relevant example of skin cancer and its effects will lay the groundwork for a basis of understanding that skin cancer can affect a broad range of the population and should be considered an important medical consideration. The goal of providing students with this information is to educate on the basics of protective nature of skin as an organ, potential for skin to become injured and diseased, and to dispel any myths surrounding the total protective effect of having a darker skin tone.

More serious burns will be introduced though relatable, pop-culture videos. One example is a small section of the Grey’s Anatomy episode Season 15 Episode 17 “And Dream of Sheep” which featured a story where they used Tilapia skin to cover a burn victim to help aid healing and regeneration of skin cells. This is a therapeutic approach to treating skin burns frequently employed by physicians in Brazil (Alves et al., 2018).

After watching and reflecting on these presentations, students will be able to conduct their own research, either on the computer or via readings provided. Students will have half a class period to become an expert on one existing solution and at the end of class students will present in groups of four what they have become an "expert" in.

The Design Process in Action (Day 6 – 9)

Following background material of the problem and possible existing solutions, students will begin the prototype project by working through the design process. They will be walked through each step of the engineering design process as they work through it.

Each day will have a new part of the process to focus on:

- Day 6: Step 1: "Discovery" and Step 2: "Interpretation"

The first step of the process is to discover through empathy. The students will select small sheets of paper that have roles or symptoms on them, of either a burn or skin cancer. Each student will then be asked to embody the role provided to them. Their partner will proceed to interview them, and they should act as though they were portraying that role. Each role will have some connection to having experienced a burn or skin cancer and require a solution. The students will individually define the problem they found through their empathizing conversations.

- Day 7: Step 3: "Ideation"

After defining the problem, students will return to their partners to discuss what they believe the problem to be and confirm with the patient if that is a proper problem to address. The partner pairs will begin to ideate possible solutions.

- Day 8 and 9: Step 4: "Experimentation" and "Evolution"

Following their ideas students will create prototypes out of everyday materials, such as pipe cleaners, paper, foil, beads, or felt, in order to bring their ideas to life in three dimensions. After designing a physical prototype to solve their problem, they will test it with their problem. Students will then gain a second "role card" which will tell them if their prototype worked to solve the solution or not. Many of the "role cards" will state that they need to change an aspect of the prototype for it to work perfectly. This will aim to further develop problem solving skills and tenacity as students learn to keep going when facing adversity.

Prototype Presentations (Day 10)

Following the creation of their projects students will have the opportunity to present their prototypes with the class. Through these presentations students will be asked to share what they created, and most importantly *how* it was created. There will be a strong emphasis on explaining the problem-solving pathway they took to create their final product. Students will also be given the opportunity to share feedback and additional means of improvement with one another.

Appendix – New Haven Curriculum Standards

Next Generation Science Standards Overview

The Next Generation Science Standards are a new set of science standards designed by states to help further K-12 science education. They are comprised of three aspects: Science and Engineering Practices, Crosscutting Concepts, and Disciplinary Core Ideas. All standards and their definitions are directly from the Next Generation Science Standards website or the National Science Teachers Association Website (NSTA) as indicated below ("Next Generation Science Standards," 2019) and (Nsta, 2019).

Next Generation Science Standards (NGSS): Science & Engineering Practices

Through this unit students will grasp a stronger understanding of the NGSS Science and Engineering Practices. These are skills that students should understand through learning conducted in science class. They are skills based, rather than curriculum based, and through this hands-on unit students will work through most of them.

The Eight Science and Engineering Practices:

All practices and their definitions are directly from the National Science Teachers Association Website (Nsta, 2019).

1. Asking questions (for science) and defining problems (for engineering): A practice of science is to ask and refine questions that lead to descriptions and explanations of how the natural and designed world works and which can be empirically tested.Students will ask questions based off of the injury scenario they are given with their partners. They will then use the design process to properly work to define the problem their partner is having before working to create a prototype.
2. Developing and using models: A practice of both science and engineering is to use and construct models as helpful tools for representing ideas and explanations. These tools include diagrams, drawings, physical replicas, mathematical representations, analogies, and computer simulations.By creating a three-dimensional prototype of a possible solution to an injury to the integumentary system, students will gain experience developing and using models. They will learn that development is an iterative process and learn the problem-solving skills that surround creation of a model.
3. Planning and carrying out investigations: Scientists and engineers plan and carry out investigations in the field or laboratory, working collaboratively as well as individually. Their investigations are systematic and require clarifying what counts as data and identifying variables or parameters.In order to keep revising their prototype, students will learn to plan and carry out an investigation as they test what is working and what is not working well with their prototype.
4. Analyzing and interpreting data: Scientific investigations produce data that must be analyzed in order to derive meaning. Because data patterns and trends are not always obvious, scientists use a range of tools—including tabulation, graphical interpretation, visualization, and statistical analysis—to identify the significant features and patterns in the data. Scientists identify sources of error in the investigations and calculate the degree of certainty in the results. Modern technology makes the collection of large data sets much easier, providing secondary sources for analysis.Although students are not taking in data in this unit in the traditional sense, with numbers and graphs, they are taking many qualitative observations. Beginning in the first steps of even defining the problem, students use their observation skills to determine the true root problem so they can begin to determine a solution. While ideating

towards a solution and through the creation of the prototype they are also using their qualitative observation skills to keep improving their prototype.

5. Using mathematics and computational thinking: In both science and engineering, mathematics and computation are fundamental tools for representing physical variables and their relationships. They are used for a range of tasks such as constructing simulations; statistically analyzing data; and recognizing, expressing, and applying quantitative relationships.Using mathematics and computational thinking is defined as using numbers and their relationships to complete a series of tasks. Although in this unit it is not emphasized or required of students, many may take this approach (numerical) as they work through designing their prototype.
6. Constructing explanations (for science) and designing solutions (for engineering): The products of science are explanations and the products of engineering are solutions.Constructing explanations and designing solutions is the foundation of this unit. Students will aim to create a solution for an existing problem through the design process, which will ultimately result in a physical solution product. Additionally, students will construct explanations as they present their solutions to the class.
7. Engaging in argument from evidence: Argumentation is the process by which explanations and solutions are reached.Students begin the unit determining their own research for solutions. Based on the knowledge gained, students will create their own prototype for solving the problem they define through the design process. At the end of the project students will engage in explaining, or arguing, why their prototype is successful and what research evidence proves this.
8. Obtaining, evaluating, and communicating information: Scientists and engineers must be able to communicate clearly and persuasively the ideas and methods they generate. Critiquing and communicating ideas individually and in groups is a critical professional activity.Students will gain experience communicating information as they present their findings to the class at the end of the project.

Next Generation Science Standards (NGSS): Crosscutting Concepts

There are seven NGSS Crosscutting Concepts that embody themes that can be applied across all scientific fields. Through this four of these themes will be addressed: Cause and Effect, Scale, Proportion, and Quantity, Systems and Systems Models, and Structure and Function.

The Seven Crosscutting Concepts:

All crosscutting concepts and their definitions are directly from the National Science Teachers Association Website (Nsta, 2019).

1. Patterns: Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.
2. Case and Effect: Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.
3. Scale, Proportion, and Quantity: In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.
4. Systems and Systems Models: A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.
5. Energy and Matter: Tracking energy and matter flows, into, out of, and within systems helps one understand their system’s behavior.

6. Structure and Function: The way an object is shaped or structured determines many of its properties and functions.
7. Stability and Change: For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.

Next Generation Science Standards (NGSS): Curriculum Standards

There are five NGSS Curriculum Standards addressed in this unit:

All practices and their definitions are directly from the Next Generation Science Standards website ("Next Generation Science Standards," 2019).

- MS-PE-LS1-1: Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.
- MS-PE-LS1-3: Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.
- MS-PE-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- MS-PE-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
- MS-PE-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

References

Alves, A.P.N.N., Lima Júnior, E.M., Piccolo, N.S. et al. Cell Tissue Bank (2018) 19: 373. https://doi.org/10.1007/s10561-017-9681-y

This reference for can be used to better understand the use of tilapia skin as a therapy for burns and reduction of scaring during healing.

Chen, Q., & Thouas, G. 2014. Biomaterials : A basic introduction. Retrieved from http://ebookcentral.proquest.com Created from jhu on 2019-05-30 18:15:23.

This is a wonderful reference for understanding the basics of biomedical engineering and biomaterials.

Fierst, Karen, Patrick Murray, Dominic Randolph, and Michael Schurr. 2011. "Design Thinking for Educators," no. April.

This resource can be used by any educator hoping to learn more about the design thinking process.

Higgins, Shauna, Azadeh Nazemi, Shera Feinstein, Maggie Chow, and Ashley Wysong. 2019. "Clinical

Presentations of Melanoma in African Americans, Hispanics, and Asians." Dermatologic Surgery, 1. https://doi.org/10.1097/dss.0000000000001759.

This resource discusses melanoma in African Americans, Hispanics, and Asians.

Hvistendahl, Mara. 2011. "How Ultrasound Changed the Human Sex Ratio." Scientific American, 1–6. https://www.scientificamerican.com/article/how-ultrasound changed-human-sex-ratio/.

This article discusses how the biotechnology ultrasound ultimately had cultural affects.

"Next Generation Science Standards." Next Generation Science Standards. June 27, 2019. Accessed June 30, 2019. https://www.nextgenscience.org/.

This website has all of the information about the Next Generation Science Standards.

Nsta. "NGSS Hub." NGSS@NSTA. Accessed June 30, 2019. https://ngss.nsta.org/.

This website has information regarding the use of the Next Generation Science Standards.

Sack, Anthony, Jon Pleat, Tom Cobley, Ian Mackie, Catalina Estala, Jackie Stephen Haynes, Rosie Callaghan, Sara Taylor, Jo Tucker, and Heather Elston. 2018. "Case Studies Series: Manukadress Ig and Manukadress Ig Max for the Management of Burns." Wounds UK 14 (5): 110–17.

Manukadress Ig and Manukadress Ig Max are two honey-infused dressings that are used as treatment options for burns.

Seol, Young Joon, Hyungseok Lee, Joshua S. Copus, Hyun Wook Kang, Dong Woo Cho, Anthony Atala, Sang Jin Lee, and James J. Yoo. 2018. "3D Bioprinted Biomask for Facial Skin Reconstruction." Bioprinting 10 (August): 1–6. https://doi.org/10.1016/j.bprint.2018.e00028.

This reference discusses a 3D printed biomask that is being developed to help aid the healing process.

Seeker. "What Exactly Does The Sun Do To Your Skin?" YouTube. August 25, 2014. Accessed March 30, 2019. https://www.youtube.com/watch?v=W0sT7mRMaj0.

This video introduces sunburns and burns.

Street, L. J. 2011. "Introduction to biomedical engineering technology." Retrieved from http://ebookcentral.proquest.com

This article is a great introduction to the field of biomedical engineering.

TED-Ed. "The Science of Skin - Emma Bryce." YouTube. March 12, 2018. Accessed March 30, 2019.

https://www.youtube.com/watch?v=OxPlCkTKhzY.

This video describes healthy, functioning skin in an engaging and exciting way. There are also curricular resources directly on this site.

Wong, Emily, Eileen Axibal, and Mariah Brown. 2019. “Mohs Micrographic Surgery.” Facial Plastic Surgery Clinics of North America 27 (1): 15–34. https://doi.org/10.1016/j.fsc.2018.08.002.

This resource describes one treatment for skin cancer, Mohs Micrographic Surgery.

Zhang, Zheng, and Bozena B. Michniak-Kohn. 2012. “Tissue Engineered Human Skin Equivalents.” Pharmaceutics 4 (1): 26–41. https://doi.org/10.3390/pharmaceutics4010026.

This paper discusses multiple advances in tissue engineering.