Innovation and Invention: Its Impact on Healthcare

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Introduction

"Discovery consists of seeing what everybody has seen and thinking what nobody has thought." -- *Nobelist Albert Szent-Gyorgyi*

I am a registered nurse from the 1990's. I practiced nursing for roughly 10 years before taking a hiatus to raise my family. Upon returning to the workforce I found myself in a teaching role at a local high school instructing students in the allied health pathway. Before I could fully embrace the purpose of my instruction, I had to first refresh the content knowledge needed to instruct my students. Wow! A lot can change in 10 years. "In the world of medicine, it's always change we can believe in."[1] No truer words have ever been spoken. I am amazed at the vast amount of change that has occurred in healthcare. Technology has ushered in many of these changes and paved the way for electronic records, robotics, laparoscopic surgery, and bionic limbs. Sure, the basic skills required to provide care to the patient have largely remained unchanged but that care can now be administered so much more efficiently and safely through many modern-day advances.

What amazes me most is that merely a decade prior, if someone had mentioned even the idea of using some of these new devices to the extent that they are used today, they would have been labeled as crazy and a fantasist. How quickly these advances have changed healthcare and how amazing to think that someone had the creativity and innovation to conceive and implement such creations. It was this thought that lead me to create this unit. I want my students to learn about the importance of ingenuity in healthcare and how throughout the ages the imagination and inventiveness of a few individuals has led to many great accomplishments in medicine.

Background

Appoquinimink High School is situated in what once used to be the rural areas of Northern Delaware. The community that Appoquinimink High School serves has quickly grown and what had once been considered rural Delaware is now suburbia.

Appoquinimink High School is located in Middletown, DE, opened in 2008, and is one of two high schools in the district. Appoquinimink School District now has plans to open a third high school within the next four years as there continues to be a mass influx of families into the area and the current two high schools are struggling to accommodate the number of students.

Appoquinimink High School enrolls over 1,600 students and was named the number one public high school in Delaware by U.S. News & World Report in 2014. This year Appoquinimink High School has implemented many of the state-model CTE (Career and Technical Education) programs of study. According to the Delaware Division of Education "these programs of study are mapped to a demand driven occupation, opportunities for students to earn college credit and an industry recognized credential."

I am an instructor for the allied health program of study. As a registered nurse I will teach the first two courses in this pathway. Each course is a semester in length and the students attend class daily for an hour and a half. The first course, *Fundamentals of Health Science* (FHS), introduces students to careers in healthcare and much of the content will have an emphasis on medical terminology as it relates to common diseases and disorders of each body system. FHS is the prerequisite to the other courses in the allied health pathway and students will receive three articulated credits at Delaware Technical Community College (DTCC) upon satisfactory completion of the course. The second course in the pathway (and where this unit will be implemented) is entitled, *Essentials of Health Careers*. In this course juniors will expand their knowledge of healthcare careers. Students will focus on career paths in the healthcare field and apply their knowledge of these careers into developing useful skills for the clinical setting. Students will receive one articulated credit at DTCC as well as certifications relevant to the healthcare industry upon completion of this course.

Rationale

During this second course, *Essentials of Health Careers*, students explore multiple career paths in the healthcare industry. While learning about the fields of medicine, nursing, radiology, respiratory, rehabilitation and other such medical areas, students will be expected to perform skills that are routinely practiced in these various career paths. Upon performing these skills, students are often required to use medical devices in order to obtain the desired data or result. Students may find themselves using a stethoscope, otoscope, sphygmomanometer, microscope, defibrillator, glucometer, pulse oximeter or manual scale. In addition to the devices that they have the opportunity to use, students will also be exposed to other medical equipment that is frequently used in these careers; this may include, radiological and imaging devices, electrocardiograms, endoscopes, and the list goes on. But where did these devices come from? What is their origin? What was it like before the invention of the stethoscope? (Hint...buried alive!) What field of healthcare is responsible for these devices and their continued improvement?

As might be expected, the field of biomedical engineering will be examined. I will incorporate this brief unit towards the end of the course. We will investigate the field of biomedical engineering as well as explore the history of medicine as it relates to medical instruments and devices. At this point in the course, students will be very familiar with a number of different medical devices, their use in the care of the patient and the possible diseases they are used to diagnose and treat. I will use this knowledge to spark their interest in primitive biomedical technology and the evolution of various technological creations.

Content

What Is A Biomedical Engineer?

This unit will begin similarly to the other units of the course by first investigating the career pathway. First, the field of biomedical engineering and the role of the biomedical engineer will be defined. Biomedical engineering is the profession in which problems in biology and medicine are analyzed and solved. This is achieved by biomedical engineers who use technology to design instruments, devices, and software to be used in the healthcare setting. Biomedical engineers who are employed by hospitals may sometimes be titled clinical engineers.

Biomedical engineers are employed in a variety of settings. These include but are not limited to hospitals, manufacturing companies, universities, research facilities, government agencies and other healthcare related facilities. To become a biomedical engineer the student must obtain a bachelor's degree in biomedical engineering or some other engineering field and then be sure to incorporate biological science electives. A few of the top biomedical engineering programs in the United States are: Johns Hopkins University, Georgia Institute of Technology, Massachusetts Institute of Technology, Duke University, University of Pennsylvania, and Boston University. The median annual salary for a biomedical engineer in May of 2105 was $86,220 and the job outlook is projected to grow 23 percent from 2014-2024, much faster than the average for most occupations.[2]

What Are The Job Responsibilities Of The Modern Biomedical Engineer?

Today's biomedical engineers have a variety of job responsibilities. The biomedical engineer may develop devices that are used to diagnose and treat medical problems. They not only designs the medical equipment but evaluate the safety, efficiency, and effectiveness of that equipment. The biomedical engineer may also design equipment for clinical laboratories, oversee automated patient monitoring and advise on rehabilitation devices.

The Engineering Design Process

There are five basic steps that are the backbone to engineering. These steps are: ask, imagine, plan, create, and improve. The purpose of these steps is to reinforce creativity, critical thinking and teamwork in solving new problems. We will look at these steps as they relate to student learning in this unit.

During the "ask" phase, students are encouraged to brainstorm what they need to know in order to solve the problem. Students should ask questions that delve into the heart of the problem. By asking questions, the student is forced to think critically. This information provides a starting point for them to develop their ideas. The next step in the design process is "imagine". This step often leads to breakthrough ideas. During this step students should be encouraged to think outside the box and to develop multiple solutions to the problem. Students should understand that there is more than one way to solve a problem.

Now it is time for students to "plan". When students reach the planning step, they are now required to focus on one design. They may work with others and "bounce" their ideas off of fellow classmates. Collaboration is encouraged, as this will lead to highly scrutinized design and thus a better quality product. Next, students will implement the "create" step. While creating their product, students ideally will build and test their idea. It is important to recognize that during this step, failure is expected. Students should not be fearful of failure, this will limit their creativity and provide a less desirable product. Finally, the last step in the design process is "improve". It is at this point that students embrace their failures and push forward with new and better ideas.

The History of Ancient Medical Devices

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. From simply providing comfort and empathy, medical care evolved with ever more effective means of diagnosing and treating illnesses.[3]

In seminar we learned that the first evidence of surgery may be a 40 year old man found in a burial ground dating 60,000-30,000 BC. The right arm was missing above the elbow and appeared to be the result of a surgical procedure. There is no way of knowing what instrument was used to amputate the arm or from what material this instrument was made, but the creation of this device could conceivably be one of the first biomedical engineered surgical instruments.

We also learned in seminar that evidence of neurosurgery can be found as early as 7000 BC. Trepanation was common in many ancient societies. Trepanation is the cutting of a hole into the skull of the "patient" and the removal of bone from the skull. This would allow evil spirits to escape (or more likely relieve the pressure from a hematoma). These early surgeries were probably accomplished with primitive blades made out of bronze, copper, and obsidian (a glasslike volcanic rock). However, as the practice of trepanation continued into the middle ages, the tools became more sophisticated and a trephine was used. The trephine was an engineered surgical tool that bore a hole into the skull. It was a cylindrical blade. The trephine is still used today in surgical procedures to remove bone and corneal tissue. The modern day trephine is an intricate device compared to the primitive tool of the middle ages.

Other forms of early bioengineered devices can be seen as early as 400 BC. The Greek historian, Herodotus, wrote of a Persian soldier, Hegistratus, who cut off his foot to escape the shackles that kept him imprisoned. Hegistratus later replaced his missing body part with a wooden version. Prosthetics have been discovered in many ancient tombs. In a Capua tomb, dating back to 300 BC, a wood leg with bronze sheets, and an iron pin was uncovered and in a mummy tomb near Thebes a fake toe made out of wood and leather was found on a female mummy. This toe was believed to be functional as it was jointed in three places and showed evidence of wear.[4] The oldest prostheses known to be used by man was just recently discovered near the Iranian-Afghan border in 2007. Archaeologists unearthed a golden artificial eye that was worn by a woman nearly 5,000 years ago. The eye was a half-sphere, just over an inch in diameter, and was made out of a lightweight material believed to be made from bitumen paste. The surface still had traces of a thin layer of gold, and was engraved with a circle for the iris. On either side of the eye were two small holes through which a thread was placed to hold the prosthesis in place.[5]

Modern Day Medical Devices and Their Origin

The Stethoscope

The stethoscope was invented by French doctor Rene' Laennec in 1816. One day, Laennec observed seeing two children playing with a plank of wood; one child scratched one end of the wood while the other child received the amplified sound on the other end. Laennec all but forgot about this encounter until he found himself examining a young woman with apparent heart issues. Unable to bring himself to place his ear upon the woman's chest in order to listen to her heart, he recalled the two playing children. Laennec is said to have rolled up pieces of paper and instead placed one end on the woman's chest and the other to his ear. With that, Laennec had developed a crude model of a stethoscope. Laennec went on to produce a stethoscope made of wood and would use his wooden tube to auscultate the sounds of the heart and lungs. He soon was able to make diagnoses based on his diagnostic findings and was able to confirm them through autopsies of his deceased patients. Laennec is considered the father of clinical auscultation and wrote the first descriptions of bronchiectasis and cirrhosis and also classified pulmonary conditions such as pneumonia, bronchiectasis, pleurisy, emphysema, pneumothorax, phthisis and other lung diseases from the sounds he heard with his invention.[6]

The Thermometer

One of the first thermometers was invented by Galileo in 1592. It was called an air-thermoscope and was used to measure fluctuations in air temperature. It was an open-ended device and highly unreliable. In the late 1600's a closed-ended glass thermometer was designed by Duke Ferdinand of Tuscany. This thermometer was filled with alcohol and remained an inaccurate measurement of temperature. In 1714 Gabriel Fahrenheit expanded on this sealed liquid in glass design and added mercury to the tube. He is also credited for devising the first standard temperature scale. Despite the now more accurate thermometer it was not used for clinical assessment because the correlation between temperature and degree of illness had not been discerned.

In 1868, Carl Wunderlich published temperature recordings from over 1 million readings in over 25000 patients made with a foot-long thermometer used in the axilla. He established a range of normal temperature.[7] It was at this point that value was placed on temperature in predicting the state of illness. However, the size of the thermometer and length of time necessary to obtain a temperature (20 minutes) detracted from its use; it was not until Thomas Allbutt designed a smaller and more convenient 6-inch model that could record a temperature in 5 minutes that the thermometer became a useful assessment tool.

The Wheelchair

The origin of the first wheelchair is unknown. The ancient Greeks used wheeled beds as early as 530 BC and wheelbarrows were used by the Chinese around 500 AD. By the 1500's, royals were using wheelchairs, more as an indication of status, then for medical need. In 1655 a paraplegic watchmaker put his skills to work and developed a self-propelling chair on a three wheel chassis. By the late 18th century, John Dawson created a rickshaw-like wheelchair. His wheelchair incorporated two wheels in back and one small wheel in front. At this point in history, the wheelchair was still widely used as mode of transportation for the wealthy.

It wasn't until the middle of the 19th century that inventors added new hollow rubber wheels similar to those used on bicycles on metal rims. By 1881 push rims were invented and by 1894 antique wheelchairs were used by veterans of the Civil War and later The First World War. In 1912 a small engine was added to make the world's first motorized wheelchair. Wheelchairs were still cumbersome to transport from one place to another until 1932 when Harry Jennings an engineer designed a folding tubular steel version for his friend Herbert Everest. Together they created Everest & Jennings a leading supply company of wheelchairs.

The Hypodermic Syringe

One of the first recorded uses of a syringe was by an Egyptian surgeon named Ammar ibn Ali al-Mawsili (900 AD). His syringe was a hollow glass tube that he used to remove cataracts from patients eyes by using suction to remove the lense. For centuries, the syringe was only used to remove substances from the human body. Early English syringes were made of pewter and silver and were heavy and difficult to maneuver. In the early eighteenth century, a French surgeon, Dominique Anel invented a small suction syringe that was made of glass, and nickel. The syringe had three rings for the fingers, which enabled its user to securely hold and use the device. It was one of the first syringes that used a plunger. Anel used his syringe as a means to clean a wound. At the time, soldiers' wounds were treated by "soldier-suckers". These were individuals who would suck the wounds of soldiers to remove any dirt or debris that was trapped in the wound. Anel's syringe was a much safer and less messy alternative.

The first hypodermic syringe was created by Alexander Wood in 1853. Wood modified the syringe of that time and added a needle. He used his syringe to administer morphine to his insomniac suffering patients. He later redesigned his syringe to include a graduated cylinder and a thinner needle. It was at this point that the use of syringes for injection became more commonplace. The syringes; however, were still made of metals and glass and had to be sterilized after each use. Eventually with the incorporation of plastic the modern day syringe became disposable.

The X-ray

British chemist William Crookes invented the Crookes tube around 1875. This was a sealed glass tube that had most of the air sucked out of it, creating a near vacuum. Crookes was able to use such tubes to observe the properties of cathode rays--streams of electrons--under different conditions.[8] Wilhelm Conrad Rontgen was a German physicist who used Crookes tubes for his experiments. One day, in 1895, he shielded the Crookes tube (which emitted a distracting glow) with a heavy black paper, and discovered a green fluorescent light glowing from a nearby screen. He called these rays that caused this glow "X" rays (X for unknown).

When Rontgen held a piece of lead in front of the electron-discharge tube, it blocked the rays, but he was shocked to see his own flesh glowing around his bones on the fluorescent screen behind his hand. He placed photographic film between his hand and the screen and captured the world's first X-ray image.[9] News of his discovery quickly spread and by 1897 battlefield physicians were using X-rays to find bullets and broken bones in soldiers of the Balkan War.

The healthcare professionals of the time did not realize the health risks of using X-rays. They believed that X-rays passed harmlessly through the body despite the occasional reports of burns, skin damage, and hair loss. An X-ray machine from the 1890's, very similar to Rontgen's original, was discovered by a medical physicist in the Netherlands. He found that to acquire an image, the body part received a radiation dose 1,500 times greater than today's dosage. There was also a marked difference in the exposure time required: It took 90 minutes to image the body part compared to 20 milliseconds using modern X-ray machines.[10]

Sanitation

Sanitation will not be covered in this unit, as I personally cover that topic elsewhere in my course content. However, depending on the curriculum of the course that you are teaching, it may be a topic that you want to present to your students. Individuals who contributed to changes in sanitation include: Ignaz Semmelweis who instructed healthcare providers to wash their hands and disinfect surroundings with calcium chloride, Joseph Lister who encouraged use of an antiseptic solution to cleanse patient's surgical wounds, Florence Nightingale who improved hygiene practices with healthcare institutions, and Louis Pasteur who proved that microorganisms are the cause for many diseases.

Creative Thought And The Advancement Of Medicine

A search on Thesaurus.com for synonmys of 'creative thought' produces such words as: artistry, awareness, fantasy, idea, ingenuity, insight, inspiration, inventiveness, resourcefulness, and vision. Do these words have any value to the world of medicine? I say, "Yes"! In fact, it is my sincere belief that creative thought is paramount to the advancement of medicine. In Morton A. Meyers, book entitled *Serendipity in Major Medical Breakthroughs in the Twentieth Century*, he writes, "Creativity is a word that most people associate with the arts. But the scientific genius that leads to great discoveries is almost always rooted in creativity, and creativity in science shares with the arts many of the same impulses."[11] According to novelist Vladimir Nabokov, "there is no science without fancy and no art without fact."[12]

Meyers summarizes that creative people are open-minded and flexible in the face of unusual experiences. They are alert to the oddity of unexpected juxtapositions and can recognize a possibility even when it is out of context.[13] Yet, there is widespread concern that American schools dampen creativity. More and more educational activists are urging for changes in our schools and the fostering of creative thought in our students. In the now infamous TED Talk by Ken Robinson, he argues that "creativity is now as important in education as literacy." It is imperative that students understand that creativity is essential to advances in healthcare. Morton Meyers states that there are three pathways that lead to creative thought: reason, intuition and imagination. [14] Intuition requires asking questions. These questions are formed not by a hunch but by cognitive skill; the ability to make judgements based on snippets of knowledge.

Isidor Rabi, the Nobel Prize-winning physicist reminisces that when he returned home from grade school each day, his mother would ask not "Did you learn anything today?" but "Did you ask a good questions today?"[15] Intuition demands not only the development of the curious mind but also the ability to see things in a fresh light. Creative thought will find an analogy where no one saw one before.

The convergence of creative thought and intuition can clearly be seen in the discovery of the electrical impulses of the heart. It first begins with the accidental discovery that the heart produces an electrical current with each contraction. While conducting experiments of frogs, two German scientist, Albert von Kolliker and Heinrich Muller, found that when they unintentionally placed the excised nerve end of one frog's leg on the exposed heart of another frog, the leg contracted with the heartbeat. Some twenty years later it was Augustus Waller, a British physiologist, who would first record the electrical impulses of the heart using a Lippman capillary electrometer. However, Waller failed to perceive the magnitude of his discovery and overlooked the utilization of these recordings in clinical practice. It was Willem Einthoven who would not only perfect the recordings of the heart's impulses through invention of his string galvanometer, but also demonstrate its value in determining cardiac irregularities. Einthoven arranged to have his "electrocardiogram' linked to the university hospital one mile away by underground telephone line to transmit the signal from the bedside of patients with cardiac abnormalities. [16] Einthoven was able to diagnose cardiac abnormalities before physicians at the patient's bedside.

> Three things are certain about discovery: Discovery is unpredictable. Discovery requires serendipity. Discovery is a creative act. Advances in medicine will come not from a committee or a research team, but rather from an individual, a maverick who views a problem with fresh eyes. Serendipity will strike and be seized upon by a well-trained scientist or clinician who also dares to rely upon intuition, imagination, and creativity. Unbound by

> traditional theory and willing to suspend the usual clinical set of beliefs, this outsider will persevere and lead the way to a dazzling breakthrough.[17]

Teaching Strategies

The teaching strategies incorporated in this unit will reflect the four "beats" encouraged by my district for instruction of our students. These five operational priorities include: creativity, collaboration, communication, critical thinking, and engagement.

Lecture

My students do not have access to a textbook except when in class. I have one classroom set of textbooks which must be shared between all my classes. Therefore, to ensure that students are introduced to the same material and content, I will often use PowerPoint presentations to provide my students with the general content needed to understand the topic that we are about to cover. These PowerPoint presentations are supplemented with short videos and periodic think-pair-shares to ensure that students are engaged and comprehending the material.

Graphic Organizers

I have found that even at a high school level, students greatly benefit from the use of a graphic organizer. Students will use a graphic organizer to organize the material that they are learning and to help them to see correlations between topics that might have been missed.

Collaborative Learning

Students will engage in a variety of collaborative learning activities. These activities will encourage students to communicate while completing the task at hand. Students will be required to ask questions of one another. Through collaborative learning students are exposed to the view points and reasonings of other students. Often times this presents a side to a topic that the teacher never even considered thus deepening a student's understanding of the topic. Collaborative learning allows students to learn from one another while requiring them to respect the views of their peers.

Field Trips

This topic provides students multiple opportunities to explore the material outside of the classroom environment. Many local colleges and universities have biomedical engineering departments. Within these facilities of higher learning are labs and centers where undergraduate students produce devices and develop solutions to modern day medical issues. By having my students visit one of these programs they would be exposed to a real world connection of what they are learning in the classroom.

Another possibility for a field trip is to a local hospital to see some of the devices they have explored in the classroom up close and personal. How wonderful would it be for students to see an MRI machine up close? Some museums offer artifacts that would relate well with the content of this unit. One such museum that is locally available to my students is the Mutter Museum in Philadelphia, PA. This museum advertises the following:

> The Museum has a vast collection of medical instruments, from the smallest suture needle to a massive Iron Lung. Some of these tools represent important milestones in the history of medicine, such as the carbolic spray apparatus invented by Sir Joseph Lister, the father of modern antiseptics, and a replica of the first-ever obstetric forceps invented by Peter Chamberlen in the 17th century. [18]

Lastly, another option for a field trip and a local favorite for my students is the The Liberty Science Center. This facility located in Jersey City, NJ offers students the ability to watch surgery in real time. Students are placed in an interactive theater where they are able to watch the operation on an enormous teleconferencing screen. Microphones are passed around so that students may interact with the surgeons and other healthcare professionals involved in the surgery. There are many different options available for students to view, but one particular selection that would fit well with this unit is robotic surgery.

Technology

Unfortunately my students do not have the ability to actively use technology in the classroom except for their phones. (This will hopefully change with a new referendum that is being proposed by my district which would allow us the finances to purchase an electronic device for each high school student.) At this time, I try to implement technology in the form of a homework assignment and then incorporate this assignment into the classroom instruction. I often accomplish this through a shared drive on Google Docs. Google Docs allows my students to work in a collaborative manner to accomplish the completion of a group project that was assigned for homework.

Classroom Activities

As mentioned earlier, this will be a brief unit that will be utilized at the end of the course.

Introductory Activity and Lecture

I will first attempt to spark student's interest in the science of biomedical engineering by showing them a video clip that exposes them to the many present day medical breakthroughs that are changing the future of healthcare. There are many *Youtube* videos that demonstrate this topic. Some appropriate choices may include:

WebMD's Future of Health with Robin Roberts:
https://www.youtube.com/playlist?list=PLZiRki7k35K2s4HIUWO2eGYdEsjc1Js8Q
Top 10 Exciting Medical Technologies of 2016:
https://www.youtube.com/watch?v=exVUmuMthps

10 Unbelievable Recent Medical Discoveries:
https://www.youtube.com/watch?v=bGtEZRUwdmY

Upon completion of the video students will be introduced to the field of biomedical engineering via lecture and PowerPoint. Questions answered through this lecture will include: What is a biomedical engineer? What are the job responsibilities of the biomedical engineer? How does one become a biomedical engineer? What are the top schools for biomedical engineering? What is the job outlook and starting salary for a biomedical engineer?

Kagan Brainstorming Activity

One of the assignments that will be given to my students will require them to research the origin of a medical device. To assist my students with choosing a medical device to research, I will first have them brainstorm the different medical devices that exist today. One of my favorite ways to implement brainstorming into my classroom in a highly collaborative way is to implement a Kagan strategy called Centerpiece. The class is first divided into groups of 3-4 students. Each group is asked to seat themselves around a table. Then each student is given a 4X6 piece of paper and an additional piece of paper is placed in the center of the table. Students are required to write one medical device on the paper in front of them and then exchange it with the paper in the center. All students in the group will continue to write down a medical device on the paper in front of them and then exchange it with the centerpiece. This continues until time is called. The only stipulation is that students may not repeat a word that is already written on the paper they are filling out. To assure that students are brainstorming the correct topic, the instructor can give students a few examples to get them started with the activity. This becomes a fast paced brainstorming activity that requires all students to participate. Once time is called groups will count the number of devices on each card and will read aloud the card with the most devices. Congratulations can be given to the team which names the most medical devices.

Integrating Technology: Shared Google Slides

One assignment given to students during this unit is the research and exploration of a medical device. Students will be allowed to choose the medical device that most interests them; however, students may not choose a device that has already been chosen by their classmate. Once students have chosen their device they will explore the origin of that device. Questions that should be answered in their research include but are not limited to: Is there evidence of this device being used in the Ancient World? Who is credited for inventing the device? How is this device used in healthcare? What changes have occurred to this device since its inception? What interesting facts can you tell us about this device? Once students have collected their research they will search for photos of their device. Two photos will be required. One photo will be of their device as it looked when it was first created and the second photo will be of their device as it looks today. Students will post their pictures to a Google Slides presentation that all have access to on a shared drive. The only information that may go on the slide is their two pictures and their name in the lower corner of the slide.

Upon completion of the Google Slide Drive students will be asked to present the material that they researched. They may use note cards to help them with their presentation as their slide will only have the two pictures. Students who are listening to the presentation will have been given a graphic organizer to help them collect the data that their classmates have researched. Through this assignment students will develop a collaborative slide presentation that they can access at any time. (Students will not be able to make changes to the presentation in the future if the instructor "locks" the presentation.)

Carousel Activity: Encouraging Creative Thought

Seven to ten pieces of chart paper will be stationed around the room. On each piece of chart paper will be written one of the medical devices that a student had presented in the class slide presentation. In groups of three, students will circulate around the room being sure to spend about three to five minutes at each station (teacher will instruct students when to move to the next station). While at the station groups must write a question that they would like to pose about the device. The thought behind the question should pertain to making the device better. For example; if students were stationed in front of the stethoscope a question may be: Is there a way to amplify the sound detected by the stethoscope in such a way that background noise is eliminated or diminished?

Once students have completed the activity the instructor will read each of the questions aloud. Discussion will occur within the class at each of the stations as the final question is read. The teacher will encourage the students to reflect on these questions and to see if these questions have prompted any other questions that the students may not have originally thought to pose.

Summative Activity: Creating A Medical Device

The unit will conclude with students developing their own medical device. My students are members of the the student organization HOSA (Health Occupations Students of America). HOSA Future Health Professionals, is an international student organization that promotes career opportunities in the healthcare fields. One benefit of HOSA is to integrate its materials into your school's health science curriculum.

HOSA provides students with competitive events in which they can compete at a national level. One such event is entitled Medical Innovation. The purpose of this event is to have teams consisting of two to four students develop a medical innovation. The guidelines for this event can be accessed on the HOSA website under "competition" and then under "guidelines".

Students will be required to follow the HOSA guidelines. However, they will only have one option and that is to create a visual display of their own original medical innovation. Students will be required to present their device in a seven minute oral presentation. In accordance with the HOSA guidelines, the presentation will explain, teach and demonstrate the medical innovation and the objective for creating the device.

Prior to beginning the summative activity the students will be introduced to the engineering design process. We will discuss all the steps of the process and implement the first three steps in class. However, due to the nature of this class and the fact that it is not an engineering course, my students will unlikely be able to test their ideas and then improve on them. Therefore, my students will not experience all the facets of the "create" step. Once my students have created their medical innovation, they will not have the benefit of testing their ideas and developing improvement. Yet despite this disadvantage, I am hopeful that my students will benefit from the act of creating and that their creativity and critical thought will be stimulated.

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Appendix A

This unit covers the following National Health Science Standards:

NHSS 1.13 Analyze basic structures and functions of human body systems

NHSS 1.21 Describe common diseases and disorders of each body system

NHSS 1.22 Discuss research related to emerging diseases and disorders

NHSS 1.23 Discuss biomedical therapies as they relate to the prevention, pathology, and treatment of disease
NHSS 3.13 Assess the impact of emerging issues on health care delivery systems

NHSS 4.32 Distinguish differences among careers within health science pathways

Notes

[1]Bonchek, (2009), 117.
[2]United States Department of Labor.
[3]Street, Laurence. *Introduction to Biomedical Engineering Technology*, 1.
[4]Strange Remains. "Golden Eyes, Bronze Legs, and Wooden Toes: Amputation and Prosthetics in the Ancient World."
[5]Strange Remains. "Golden Eyes, Bronze Legs, and Wooden Toes: Amputation and Prosthetics in the Ancient World."
[6]Roguin, Ariel. "Rene Theophile Hyacinthe Laennec: The Man Behind the Stethoscope."
[7]Pearce, J.M.S. "A Brief History of the Clinical Thermometer."
[8]Bryant, Jill. *Inventions That Shaped the Modern World: Medical Inventions*. 20-21.
[9]The Scientist. "The First X-ray, 1895."
[10]The Scientist. "The First X-ray, 1895."
[11]Meyers, Morton A. *Happy Accidents*, 15.
[12]Meyers, Morton A. *Happy Accidents*, 15.
[13]Meyers, Morton A. *Happy Accidents*, 17.
[14]Meyers, Morton A. *Happy Accidents*, 14.
[15]Meyers, Morton A. *Happy Accidents*, 14.
[16]Meyers, Morton A. *Happy Accidents*, 191.
[17]Meyers, Morton A. *Happy Accidents*, 24.
[18]The Mutter Museum. "Instruments."