Brain Surgery Across the Ages: Stones to Advanced Technologies

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If the human brain were so simple that we could understand it, we would be so simple that we couldn't.
-Emerson M. Pugh[1]

Rationale

Drilling holes into skulls without anesthesia, a gentleman who appears "normal" until he removes his hat to reveal half of his head missing, gravesites of skulls with missing pieces. Now, these are stories that will invoke my students' curiosity that may be forgotten at times in our schools' curriculum. For me, this unit addresses two weaknesses that I feel I have. First, it is developed for my College Preparatory (CP) Psychology course that I do not believe I always give the same attention to as my Advanced Placement (AP) or Dual Enrollment courses. This brings it to the forefront of my instructional planning which is very important. By using a combination of texts – written and visual, I will be better able to capture the attention of my students that struggle with reading vast amounts of materials. Second, it has made me look in-depth at the Biological Bases Unit, that, I believe to be my weakest knowledge base. Grasso's comment, "Studying the development and role of technology in ancient times will help us better understand and contextualize the massive and unparalleled power at our fingertips today" made me conceptualize the importance of having my students understand the historical component of brain surgery – how did it all begin (which I believe will be surprising to them), and how have our technological changes affects this type of surgery.

Objectives

I follow the American Psychological Association's national Psychology Standards for my College Preparatory (CP) Psychology course. These standards are divided into seven domains. This unit will focus primarily on the *Biopsychological Context Domain* to include three objectives from the Content Standard Four within this domain – Methods and Issues Related to Biological Advances: (1) Identify tools used to study the nervous system (2) Describe advances made in neuroscience; and (3) Discuss issues related to scientific advances in neuroscience and genetics. Additionally, the unit will address one of the Common Core Standards: Integration of Knowledge and Ideas/CCSS.ELA-Literacy.RH.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, as well as in words) in order to address a question or solve a problem. The questions being: How has thinking differed from past versus present in how to study the brain? and How do these changes in thinking give us a better understanding of the brain?

The curriculum unit will be divided into three parts: (1) Cognitive Revolution (2) Yesterday's Tools of Discovery; and, (3) Today's Tools of Discovery. A variety of texts to include the A

History of the Brain: From Stone Age Surgery to Modern Neuroscience and primary sources (excerpts from various books and visual texts) for students to read through that demonstrate information to include personal accounts so that students see the *human* component of these concepts.

The **Enduring Understandings** for this unit are formulated from the Psychology Standards. After the unit, students will understand *how and why the human brain developed over time* and that *there are various tools (past and present) used to study the nervous system.* Additionally, they will know that *an evolution of advances have been made in neuroscience which enable us to better understand the nervous system and that these advances have created issues in neuroscience and genetics.* **Essential Questions** to guide the unit include: *What are the technologies that have been used to study the brain in the past and in the present? How do these technologies assist us in better understanding the brain?* and *What are the commonalities of the past with today's technologies?*

Demographics

Conrad Schools of Science is a school that is a science/biotechnology magnet school serving a little over 1200 students in grades 6 – 12. It is considered an urban school, situated on the outskirts of the most populated city in the state of Delaware, Wilmington. CSS students come from all over our state's largest county. The school's popularity is obvious as many families complete the *Choice* application process seeking admission to our school. At the high school level, students can choose to focus on a variety of learning "*strands*" such as biotechnology, physical therapy/athletic healthcare, biomedical science, animal science, and computer science. Our high school is the only one in the state that is not a vocational-technology (vo-tech) school to offer a Delaware Certified Nursing Assistant (CNA) program.

Additionally, a variety of Advanced Placement (AP) courses are offered as well as multiple courses that are in conjunction with our local community college and university. I am the teacher of one of these courses, *Sociology*. This dual-enrollment course in which students (juniors and seniors) are enrolled at the local community college and receive credit from that institution upon successful completion of the course with me on the high school campus. Moreover, it is a *distance-learning course* in that some of my students are at my school while others are at a sister school in our district. The course happens real-time – at the different locations – same teacher (me!), curriculum, activities, etc. This is my fifth year teaching in this manner. I am continuing to try to master this type of teaching/learning environment as well as the content that I had not interacted with in many, many years.

This curriculum unit is designed for the high school juniors and seniors who choose to take this social science course, CP Psychology. This course does count as credit towards their fourth (and final) social studies requirement, but it is offered as an elective.

Technology

I thought I knew what the term technology meant before I became an Ancient Inventions Seminar Fellow! In fact, it is still a term that I am grappling with, as I know my students will as well. Initially, I thought of it as things that I use such as my car to drive far distances, the television to watch my favorite programs, and the computer to email fellow colleagues. When I thought about it more deeply, I began to compare my life now to that of when I served in the Peace Corps in a small village in the Andean Mountains - what were the things that made life easier? Instead of scrubbing my shirts on a rock I now have a washing machine to clean my clothes, instead of needing to boil my water and save it in a storage tank I can just turn the faucet on in my house or get a bottle of water that I purchased. An appreciation of what technology has done to ease my workload came to mind. If I asked my students what is technology, I know they would reply cell phones, video games, and computers. However, from Grasso's seminar, I have come to better understand technology as more global and hope that I can enhance my students' definition as well.

We began our seminar last spring reading two excerpts about technology. In Hughes's Introduction to his book, Human-Built World: How to Think About Technology and Culture, he writes about Jacob Bigelow (1831) who believed technology was not only artifacts but also the processes that conceptualize and realize them.[2] Highlighting Bigelow's thoughts of technology as creativity reminded me of Bobby, a Fellow in our seminar who is an artist as well as art teacher at a local elementary school. His creativity allows him to produce jewelry pieces that are artifacts of technology. He separated sciences from technology, of which the term has mostly been referred to, which is how I was thinking about the term. He stated, "The sciences are discovered, not invented."[3] The term, technology, came into focus in the twentieth century and began to be used more consistently. The founding members of the *Society for the History of Technology* decided on this particular name for their group – using technology instead of engineering. Hughes confirms this more global thought pattern when he further adds technology is associated with engineering as well as architects and artists highlighting the "aesthetic dimensions of technology."[4]

In The Nature of Technology, Arthur states that "we have no agreement on what the word 'technology' means, no overall theory of how technologies come into being, no deep understanding of what 'innovation' consists of, and no theory of evolution for technology."[5] He writes a series of questions, "What is technology? What is it in the deepest sense of its nature? What are its properties and principles? Where does it come from – how does it come into being? How does it develop? And how does it evolve?"[6] Furthermore, Arthur writes "novel technologies arise by combination of existing technologies and that (therefore) existing technologies beget further technologies"[7], "machinery moves in response to thought and to thought alone"[8], and technology "creates our wealth, our economy, our very way of being."[9] These comments lead into the idea of a cognitive revolution. One technology or creative thought builds upon another and that each one is intertwined into which we are.

Tool making

When I began my journey to learn more about brain surgery I first thought about the fact that tools – of course – were needed. In my mind, no pun intended (!), I assumed stone tools were used although I was ignorant in my thought processes. Fortunately, I visited with Dr. Tom Rocek, a University of Delaware (UD) professor who shared his expertise on knapping (stone making) with me. The first thing that struck me about Dr. Rocek was his passion for the content. We spoke in the UD's Anthropology – what I would call meeting room – first where he explained about the different time frames in regard to tool making – stone, iron, metal. He knew immediately that drilling into the brain, trepanation did not occur until the Neolithic time frame although he also mentioned there might be some contradictory information regarding this fact.

Stone/tool making is referred to as knapping. Dr. Rocek spoke of the physical strength that is needed by flintknappers. Showing me various tool samples, he pointed out that the rock is considered the core. The flakes are what is "hit off" of the core. He also spoke to the changes that occurred over time in how these tools were made. At first, the early flakes were the main focus not the shape of the tools. The shape is what is associated with human modification. Anatomically and brain wise (which I later learned in my readings) helped to ensure the creativity and curiosity of these modifications. Each of the groups before us contributed to these modifications: Homo Erectus demonstrated control; a bi-face systematic work on both faces of the flake; Mesolithic enabled the use of grinding, cracking, and miniature tool making, and the Neanderthal evidence of a multi-step process of the core and flakes producing a "turtle back" of short repetitive strikes. Afterwards, we went to his laboratory where he demonstrated making flakes from rocks. We spoke of how students might be able to emulate this practice and what materials would be needed to dissect the sheep brains a colleague had ordered for me. Dr. Rocek thought getting sheep heads (skulls in tact) would be better for the tool-making component of this unit. However, after reading a few of the articles that his wife and colleague, Dr. Karen Rosenberg suggested (*Tales of a Stone Age Neuroscientist* by Dietrich Stout and *The First Technology* by Nicholas Toth), I do not know if this is feasible or desirable since Stout referred to the hundreds of hours he had practiced to create his tools.

Stout's article, *Tales of a Stone Age Neuroscientist*, proved very valuable and coincided with the book that Seminar Leader, Grasso recommended, Sapiens. The article focused on using today's technology to better understand "past peoples technology" by looking at how cognition evolved over time by scanning their own brains while creating tools. Stout writes to the difficulty of creating these tools, "Knowing what you want to make is not the hard part. The difficulty lies in actually making it."[10] The author equates the refined practice of tool making to lie in many, many hours of practice and equates it with the time necessary in academic studies. He claims there are three factors involved: motivation, self-control, and an understanding of the materials. [11]The author states that it takes "long and painstaking practice"[12] and that our ancestors' lives depended on their honed skills. In fact, he purports that these skills, along with the social interaction system necessary to teach them, might be the reason for the "human cognitive evolution."[13]

In the experiments conducted, tool-making experts' brains were monitored using a tool, the FDG-PET (flurodeoxyglucose positron-emission tomography) in which an intravenous line was

administered to monitor the "supply the radioactive molecule used in PET to image brain activity. The tracer is taken up in metabolically active tissues in the brain."[14] After which a scan is run to see where the "chemical has accumulated."[15] From this, the scientists were able to determine that the "amount of force applied during the percussive strike to detach flakes efficiently from the core"[16] initiated an "increased activity in the supramarginal gyrus in the parietal lobe, which is involved in awareness of the body's location in its spatial environment."[17] The techniques used require control but careful planning as well. Multiple areas in the left and right hemispheres of the brain "lit up" when toolmakers were working. Evidence concluded that more of the brain gets used while performing the task. Further studies were conducted using new technology, a "diffusion tensor imaging (DTI), a form of MRI that allows scientists to map the white matter fiber tracts that serve as the brains' 'wiring'".[18] Studies showed that the white matter tracts were enhanced, similar to the other studies. Additionally, it included the "right inferior frontal gyrus of the prefrontal cortex, a region critical for cognitive control."[19] This continues to increase with more practice.

The Cognitive Revolution

In Sapiens, Harari writes of three revolutions that have occurred: Cognitive (70,000 years ago), Agricultural (12,000 years ago), and the Scientific (about 500 years ago). I imagine most of my students would not equate advanced cognitive abilities with those who lived 70,000 years ago, viewing them primitive in nature. They would, however, recognize the term Agricultural Revolution as that is something that is taught in the middle and high school social studies curriculum. Scientific is what I think they would relate to as "technology" and may think of the Industrial Revolution as part of this concept. For this unit, I will focus on Harari's explanation of the Cognitive Revolution.

Our brains are large compared to other animals. In a 130 pound mammal, a normal size brain is 12 cubic inches, the earliest men and women's brains around 2.5 million years ago were about 36 cubic inches while modern Sapiens (us) have brains the size of 73-85 cubic inches.[20] Since our brains are big, they require bodily resources. Although it only constitutes 2-3 per cent of our body weight it uses 25 per cent of our energy while resting.[21] This meant that our ancestors spent more time looking for food (to sustain our brain and its' development) and our muscles atrophied. These finely tuned muscles that later developed were able to create sophisticated tools. According to Harari, it appears as if there was some type of accidental genetic mutation that changed the "inner wirings of the brains of Sapiens" enabling them to think and communicate in new ways.[22] There are three new abilities that Sapiens acquired: (1) the use of language allowed for us to share larger amounts of information which helped in "planning and carrying out complex actions, such as avoiding lions and hunting bison"[23] (2) the ability to convey information for allowed for the formation of bigger groups (up to 150 people), and (3) in doing so, strangers were able to interact and cooperate – "revising their behavior to changing abilities enabled them to invent items such as boats, oil lamps, bows and arrows, and needles as well as religion, commerce, and social stratification systems[24]including that which does not exist."[25]. Our knowledge of those before us, before history was written down, comes mainly from their burial sites. Wickens writes that burial practices reveal changes in behaviors. It

speaks to the fact that "man is beginning to question the world and become self-aware of his own existence. It is arguably the first-evidence that consciousness is emerging from the human brain."[26]

Brain Surgery

Remains at burial sites have provided us with evidence of what brain surgery in the past must have looked like, how it was performed, tools used, and survival rates. Having an understanding of when and how it began will enable students to better comprehend today's procedures. The New Stone Age (or Neolithic) period, roughly corresponds to an era spanning from 3000 to 18000BC. This is a time in which there is evidence of farming practices, polished stone tools, pottery, and small settlements. Additionally, it is the first evidence of brain surgery! "The first perforations of the human skull performed by surgical procedures with specialized stone tools. Thus, Neolithic man was using scrapers and sharp instruments to perform an operation known as trepanation (from the Greek trypanon meaning 'to bore'), which is the earliest known surgical procedure to have been undertaken by mankind."[27]

Trepanation or Trephination

Conflicting stories have the first found trepanation skull ending up with Paul Broca. One account states that the skull was found during the 1830s in an Incan Peruvian cemetery, given to the American diplomat Ephraim George Squier who later gave it to the New York Academy of Medicine in 1865. From there it was sent to Broca in Paris in 1867.[28] In another account an archaeologist excavating a Stone Age tomb came across a skull with a hole cut into it. Next to it was the piece that had been cut. This archaeologist believed the cut piece to be a perfect drinking vessel. Since this thought process went along with the common belief that ancestors were savages, it was taken for granted to be true.[29]It wasn't until a few years later when the skull was delivered to Paul Broca's laboratory in Paris, France where he determined that "the supposed 'polish' was actually *regrowth of the bone tissue after cutting*. A cut bone surface reveals tiny pores that are easily visible to the naked eye. When the bone heals after cutting, tissue builds up, blocking the pores to give a smooth appearance. No other process but healing could have produced such a surface."[30]I find this story very interesting in that for all the advances in technology, Broca and his colleagues were unable to perform with success what had been done on this 4,000 year-old skull!

Trepanation, trepanning or burr holing is a medical intervention in which a hole is drilled, incised, or scraped into the skull, removing the bone and exposing the dura mater using simple surgical tools"[31]Evidence of this operation was found in many burial sites around the world's civilization except for Egypt in which it was taboo to interfere with the body until after death in which organs are taken from the body and put into canopic jars. Evidence from 214 Incan skulls showed that survival rates from these procedures were pretty high. In fact, 55 per cent of the skulls showed complete healing and only 28 per cent of them died without a trace of healing.[32]In France, from around 6500 BCE, 120 skulls were found of which forty had evidence of

trepanation with a decent survival rate, showing healing to indicate that many lived for years after the procedure.

Why was trepanation used? One reason was the release of evil spirits/demons in one's head. Now known as psychological disorders, these diseases were once thought to be invaders in a person's mind, including epileptic fits. During the Middle Ages, Monks used trepanation for skull fractures most likely due to battle wounds "relieving the stress caused by splinters of bone touching the brain."[33]This was determined by evidence demonstrating that the left side or front of the head was usually operated on which would make sense as 90 percent of the population was/is right-handed and would hit the those areas in face-to-face combat.[34] Both the Celsus (A.D. 30) and Hippocrates (late fifth century B.C.) wrote about using this procedure to relieve persistent headaches and injuries, enabling pressure on the brain to subside. The Greco Roman doctors' detailed written descriptions allow us to understand how serious this medical practice.[35] Lastly, removing worms, beetles, and centipedes – what we refer to now as parasites from the brain. "Cysts expand with the growth of the worm. They produce headaches, loss of vision, and fits before the sufferer lapses into unconsciousness."[36] Additionally, some cultures used trepanation in ritual practices.

Although in present day, trepanation is rare to none, not so much in the distant past, was the practice used. In Kenya, the Gusii people in Kisii District were still using this procedure. For example, "This (apparently a highly primitive form of trephining) consisted of making an incision in the scalp, pulling the skin aside and scraping or cutting the bone of the skull until a hole was caused and the dura mater exposed. Whether the object was to remove pieces of fractured bone or to reduce pressure on the brain does not appear from the record. The wound was then covered with cow fat and bound with a cloth."[37] In 1958, in the Hat On, Hat Off case, a fifty-year-old Kenyan man, stated that when he was about forty years old and working as a tribal policeman, he was hit on the head with a door lintel (structural piece spanning the length of a door that could be wall bearing). Afterwards, he experienced chronic headaches. In 1945 and over the course of seven or eight years, he had five trepanations to try and alleviate the pain. Although some discrepancies appear in the story, he was fitted with a plastic skullcap, and appears normal looking until taking off his hat in which a portion of his head is no longer there. Students will read the article, 'Hat on- hat off': trauma and trepanation in Kisii, western Kenya, which I found depicting his story, including the psychological turmoil he faced afterwards.

There is also quite a bit of information available on the Internet regarding self-trepanation. The advocates claim that it increases blood flow within the brain, enhancing productivity and health benefits.

Trepanation Tools

Tools for this procedure vary according to time period and geographical location. Neolithic tools include sharpened pieces of stone used to scrape away the skull bone. Over time, advances occurred to include "grooving, boring, and cutting with sharp edged tools."[38] Those performing

these procedures had to have been excellent medical practitioners as the cutting of the scalp to expose the skull bone needed to be executed in an expert manner as to not kill the patient. Evidence of a Roman surgeon at Bingen on the Rhine, Germany in this tomb dated the early second century A.D. included a bronze trepanning kit with a tube-shaped drill with a removable center pin to guide it in first stages of operation, a bow to drive it, and a cup to protect the surgeon's hand.[39] The Celts of Ancient Europe also left evidence behind of the saws they used in this practice. This saw with a "wedge-shaped edge that prevented the blade from penetrating the bone more than a few millimeters at a time and damaging the underlying tissue"[40] demonstrated the advancement of the tools used in the procedure. Many issues arose due to the unsanitary situations in areas that were being used for procedures. The development of tools such as anesthesia in 1846 and the use of carbolic acid to sterilize surgical instruments/equipment and wounds in the 1860s changed the landscape of surgical procedures. The use of these tools enabled practitioners to expand their abilities and left patients to a better chance at recovery.

Tools to Examine Our Heads Today

Neuroscientists have used the following to better understand the brain – it's structure and functions: accident, lesion, electroencephalogram (EEG), CT (computed tomography) scan, PET (positron emission tomography) scan, MRI (magnetic resonance imaging), and fMRI (functional MRI). As per our psychology standards, students should be able to identify each of these tools and explain the reasoning behind their use.

Accidents are one way in which we have learned a lot about the brain. The most famous case, one in which all psychology students should be aware of by the end of their introductory course is Phineas Gage. On September 13, 1848, Phineas was on his job as a foreman of a railroad track construction crew in Vermont. This twenty-six year old, all around great guy was on the job with his tramping iron, an iron pole of about three and a half feet used to pack down loose gunpowder in holes that were made by his assistant. Phineas and his assistant had performed this delicate process thousands of times without any issues. On this particular day, something went wrong – evidence is conflicted of who was at fault – and an explosion occurred. Whatever the case, the rod ended up entering Phineas's head below the cheekbone, behind the left eye and into the front of the brain. He never lost consciousness, was able to carry on conversations with his co-workers and the physicians who attended to him. He survived the incident. However, he became a changed man. His brain functions changed. Instead of a well meaning and mannered young man, Phineas had turned in to someone who was unreliable, nasty, and vulgar.[41]

The term lesion literally means damage. "Tiny clusters of normal or defective brain cells" are damaged while those around them are left undamaged/unharmed. From these studies of *brain mapping*, neuroscientists have been able to determine the damaged section causes certain symptoms. For example, damage to the back of the brain (occipital lobe) causes issues with sight, damage to one side of the brain causes numbness/paralysis in the other as in strokes, issues in the Broca's area causes difficulty in speech production. This information helped to identify specific regions of the brain – the structures and their functions.

Today's tools enable us to study the brain, to better understand the electroencephalogram (EEG) records the "electrical activity in the brain's billions of neurons sweeps in regular waves across its surface".[42] Electrodes are attached to sensors and wires to detect the electrical activity. This activity is recorded as wavy lines. The test is done for multiple reasons including to detect seizure activity. Other reasons include: when someone is in a coma to determine if there is brain activity, sleep disorders, or an issue with the nervous system.[43]

The CT (computed tomography) scan is used to determine brain damage by taking a series of horizontal (slices) detailed X-rays. "In computed tomography, the X-ray beam moves in a circle around the body. This allows many different views of the same organ or structure. The X-ray information is sent to a computer that interprets the X-ray data and displays it in a two-dimensional (2D) form on a monitor."[44] The PET (positron emission tomography) scan is used to show the brain's activity through its' consumption of sugar/glucose. The radioactive glucose is a tracer that can be inhaled, swallowed, or injected. "The tracer collects in areas of your body that have higher levels of chemical activity, which often correspond to areas of disease. On a PET scan, these areas show up as bright spots."[45] This particular tool is helpful in diagnosing some cancers and brain disorders. An MRI (magnetic resonance imaging) uses a magnetic field "which aligns the spinning atoms of brain molecules. Then a radio-wave pulse momentarily disorients the atoms. When the atoms return to their normal spin, they release signals that provide a detailed picture of the brain's soft tissue."[46] There are various reasons for using this type of tool. It "can look at the brain for tumors, an aneurysm, bleeding in the brain, nerve injury, and other problems, such as damage caused by a stroke. MRI can also find problems of the eyes and optic nerves, and the ears and auditory nerves."[47] When students learn about the psychological disorder of schizophrenia, they will learn that the MRI shows enlarged, fluid-filled areas as compared to the brain of one without the disorder. The last tool, the fMRI (functional MRI), details the structure and function of the brain. Through the use of magnetic imaging, it can diagnosis issues and diseases as well as detail how the patient is thinking and what he is feeling.

Strategies

Collaborative Learning/Group work

Students need to learn how to work together to accomplish goals – those set by the teacher and themselves. This is a basic requirement for many positions or jobs that they will hold in the future. Working together, relying on each other helps to build team-working skills. This strategy is somewhat challenging for us in that there are two groups of students at three different high schools. For the intense conversations that follow the readings of important concepts such as gender, race, or religion a facilitator must be certain that there is a strong sense of camaraderie, trust, and willingness to work with and listen to others in the group. In collaborative learning, each group member is accountable to each other, dependent upon each other and contributes the established goals. Everyone has some strength to share.[48] Together, more is accomplished. Opportunities to learn about each other before and while working help to promote the collegiality and cohesiveness necessary to work well together. Individual and group evaluations are

necessary to monitor the group's work (product) and their progress in teamwork. This is essential especially for our environment of bringing students from three schools together via cameras and technology.

This year I will continue to take the use of this strategy even further. Many college courses are now using this feature. Students post on-line outside of class and are scored/graded on the quality of their posts. I will work with the students at the beginning of our time together to establish a rubric that will be used for them to be graded for their posts. I have noticed from teaching this course before that students need to cite the evidence within their work as reflected in the rubric (to score well). They need to identify this evidence in their work so that they can truly "see" it to understand why or why not they receive credit. As much as possible, I want to emulate what they will experience next or the following year at college.

Flipped Classroom/Just-In-Time Learning

Although I am new to this, I am trying to use this methodology more as our school district now uses an on-line Learning Management System (LMS), Schoology. Although I have been using an LMS for the past six years for my Sociology course, I did not actively do the same for my Psychology courses. Due to the encouragement of our district regarding the newer LMS, Schoology, I am beginning to respond and structure opportunities for my students to read, take a quiz, and write to a prompt outside of class. When Grasso met with me to discuss my unit, he mentioned the *Just-In-Time Teaching (JiTT).* After reading up on it, I believe it to be very similar to the *Flipped Classroom* philosophy. *JiTT* uses three types of activities with students, which they should complete outside of class: Warm-Ups (complete a reading and answer questions), Puzzles (serves as a wrap-up for what was discovered in class), and GoodFors (an activity that provides an opportunity for a real-world connection).[49] My take-away from this reading is the use of student comments in their on-line Warm-Ups to enhance and extend conversations/work in the classroom.

Activities

Students' taking the lead is the central idea for each of these activities. I want to provide more of an opportunity for *discovery* as this in the spirit of the entire seminar.

Brain Stories

The first activity before studying anything about the structures and function of the brain will be for students to strategically assigned one story to read from the book, The Tale of the Dueling Neurosurgeons. This book provides strange enough stories to capture students' attention about the misfortunes of others. Each account focuses on the brain and its' functions or malfunctions. I believe students will be engaged as the read the one chapter. We will use a Jigsaw Method in which students will individually become experts on one story and then be grouped with others to share their findings while also learning about other stories from their group members. Each group will create a visual detailing their stories similarities and differences focusing on the brain.

Afterwards, we will focus on our textbook's information regarding the structure and function of the brain to include the Nervous System. These stories will enable students to better understand cognitive developments and connections.

Today's Tools of Discovery

Students will be given a list of the following tools in which neuroscientists study the brain's connections to behavior: accident, lesion, electroencephalogram (EEG), CT (computed tomography) scan, PET (positron emission tomography) scan, MRI (magnetic resonance imaging), and fMRI (functional MRI). Each student will read the textbook to get a general idea about each of these tools. Then, students will choose one of the seven tools and investigate it through other texts and on-line resources to synthesize these multiple resources and provide an advertisement of the chosen tool explaining the how and why of the tool – what are its' advantages.

Yesterday's Tools of Discovery

In this activity, students will focus first on trepanation. Students will view multiple sources (reading and visual materials) regarding this procedure. I believe that students will find this very interesting – the stories of multiple skulls discovered with holes in them, the man with half a head, drilling, cutting into and scraping the scalp, amongst others. A Socratic Seminar will follow with the discussion focusing on their understandings of the procedures including the tools, the fascinating stories, and questions they must still have. Afterwards, an investigation will be announced, in which small groups will determine how they could re-create the surgical procedure of trepanation on a human skull. Students will explain their plan (procedures) via video so that the plans can be compared with each other to determine similarities, differences, and rationale.

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Appendix

The American Psychological Association's national Psychology Standards are used for this unit. This unit will focus primarily on the *Biopsychological Context Domain* to include three objectives from the Content Standard Four within this domain – Methods and Issues Related to Biological Advances: (1) Identify tools used to study the nervous system (2) Describe advances made in neuroscience; and (3) Discuss issues related to scientific advances in neuroscience and genetics. Additionally, the unit will address one of the Common Core Standards: **Integration of Knowledge and Ideas/CCSS.ELA-Literacy.RH.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media** (e.g., visually, quantitatively, as well as in words) in order to address a question or solve a problem. The questions being: How has thinking differed from past versus present in how to study the brain? and How do these changes in thinking give us a better understanding of the brain?

The **Enduring Understandings** for this unit are formulated from the Psychology Standards. After the unit, students will understand *how and why the human brain developed over time* and

that *there are various tools (past and present) used to study the nervous system.* Additionally, they will know that *an evolution of advances have been made in neuroscience which enable us to better understand the nervous system and that these advances have created issues in neuroscience and genetics.* **Essential Questions** to guide the unit include: *What are the technologies that have been used to study the brain in the past and in the present? How do these technologies assist us in better understanding the brain?* and *What are the commonalities of the past with today's technologies?*

Students will be able to synthesize multiple texts (written and visual) about They will individually read many different texts such as our textbook, individual patient cases, and on-line articles. While reading and viewing, they will take copious notes to use during the communal to share the information with their group members, create an advertisement of one of today's technologies, and determine how to dissect a sheep's brain most effectively to determine its' structures.

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[2] Thomas P. Hughes, *Human-Built World: How to Think about Technology and Culture*, 3.

[3] Ibid.

[4] Ibid, 5.

[5] W. Brian Arthur, *The Nature of Technology: What It Is and How It Evolves*, 13.

[6] Ibid, 12.

[7] Ibid, 21.

[8] Ibid, 9.

[9] Ibid, 10.

[10] Dietrich Stout, *Scientific American*, April 2016, 32.

[11] Ibid, 35.

[12] Ibid, 32.

[13] Ibid.

[14] Ibid.

[15] Ibid.

[16] Ibid.

[17] Ibid, 33.

[18] Ibid.

[19] Ibid, 34.

[20] Yuval Noah Harari, *Sapiens: A Brief History of Humankind*, 8.

[21] Ibid, 9.

[22] Ibid, 21.

[23] Ibid, 37.

[24] Ibid, 21.

[25] Ibid, 22.
[26] Andrew P Wickens, *A History of the Brain: From Stone Age Surgery to Modern Neuroscience*, 4.
[27] Ibid.
[28] Ibid.
[29] Andrew P Wickens, *A History of the Brain: From Stone Age Surgery to Modern Neuroscience*, 24.
[30] Ibid.
[31] Jenni Irving. Trephination *Ancient History Encyclopedia*, last modified May 01, 2013, http://www.ancient.edu/Trephination/ (accessed on October 10, 2016).
[32] Peter James and Nick Thorpe, *Ancient Inventions*, 26.
[33] Ibid.
[34] Peter James and Nick Thorpe, *Ancient Inventions*, 27.
[35] Ibid.
[36] Peter James and Nick Thorpe, *Ancient Inventions*, 29.
[37] Sloan Mahone, *History of Medicine*, Oxford University, Oxford, UK Published online: 03 Apr 2014. 'Hat on- hat off': trauma and trepanation in Kisii, western Kenya.
[38] Andrew P Wickens, *A History of the Brain: From Stone Age Surgery to Modern Neuroscience*, 6.
[39] Peter James and Nick Thorpe, *Ancient Inventions*, 29.
[40] Ibid.
[41] John Fleischman, *Phineas Gage: A Gruesome but True Story about Brain Science*, 20.
[42] Amy C. Fineburg, *Myers' Psychology For AP (Teacher's Edition)*, 67.
[43] http://www.webmd.com/epilepsy/electroencephalogram-eeg-21508 (accessed December 20, 2016).
[44] http://www.hopkinsmedicine.org/healthlibrary/test_procedures/neurological/computed_tomography_ct_or_cat_scan_of_the_brain_92,p07650/ (accessed December 20, 2016).
[45] http://www.mayoclinic.org/tests-procedures/pet-scan/basics/definition/prc-20014301 (accessed December 20, 2016).
[46] Amy C. Fineburg, *Myers' Psychology For AP (Teacher's Edition)*, 67.
[47] http://www.webmd.com/a-to-z-guides/magnetic-resonance-imaging-mri#1 (accessed December 20, 2016).
[48]http://www.studygs.net (accessed July 13, 2009).
[49] https://cft.vanderbilt.edu/guides-sub-pages/just-in-time-teaching-jitt/ (accessed December 20, 2016).