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Apprenticeships in Scientific Research: Exploring Brain Functioning in a Research Lab and in a Seventh Grade Classroom

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Apprenticeships in science research settings allow teachers to participate in the scientific community and develop a more sophisticated view of the practice of science.

A Science Research Apprenticeship for Teachers

The Chicago Science Teacher Research (CSTR) program is an initiative by the faculty of four University of Illinois at Chicago (UIC) Colleges, directed by Dr. Andreas Linninger and in cooperation with the Chicago Public Schools (CPS) and industrial-interest groups, to address the need for engaging in-service teachers in emerging technologies. Participant teachers (called RET Fellows) investigate topics in domains such as, material sciences, nanotechnology, and biomedical and environmental engineering.

Apprenticeships in science research settings allow teachers to participate in the scientific community and develop a more sophisticated view of the practice of science (Richmond, 1998; Varelas, House, & Wenzel, 2005). One of the end goals of such apprenticeships is that teachers bring their experiences back into the classroom to benefit their students' learning. Since a decade ago, Cunningham and Helms (1998) have claimed that such an experience is needed in order to give teachers "the requisite knowledge—both sociological understandings of science and pedagogical knowledge" (p. 493). Studies have shown that apprenticeships in science research settings can enable teachers to implement worthwhile research experiences in their classrooms (Helmer, 1997).

In the summer of 2007 the principal author, Amani Abuhabsah, had the opportunity to be a part of the UIC CSTR program. In this program, RET Fellows work with a faculty mentor doing scientific, cutting-edge research, using state-of-the-art experimental and computational facilities, and sharpening their scientific and mathematical knowledge. They also take a bioengineering course at the graduate level. The RET Fellows attend weekly meetings and presentations, and they present weekly updates of their projects by giving presentations. A final report and presentation are the culminating artifacts of the summer experience, that is extended during the school year with a few meetings where RET Fellows share teaching modules that they have designed for, and implemented in, their classes related to their research. The rest of this article is written in the first person, capturing Amani's research experiences in the lab, and the types of research activities that she designed and implemented subsequently with her seventh grade classroom related to the topic she studied.

The NEAL Lab and My Project

My apprenticeship entailed working on a project that dealt with stroke rehabilitation through electrical stimulation in rodent models in UIC's NEAL laboratory (Neural Engineering Applications Laboratory), led by Dr. Rousche. One of the latest accomplishments of the NEAL lab is a new device to better understand the complexity of stroke damage by combining multiple techniques. The device incorporates stroke induction, and neurochemical and neurophysiological sensors. It measures electrophysiological brain signals before, during, and after stroke in the rat motor cortex, in an effort to characterize cortical neuroplasticity. The multi-modal device incorporates neurotechnology development in order to create a method to accurately assess bio-chemical-electrical spatiotemporal dynamics related to single neurons and/or multi-neuron clusters. The device will allow researchers to achieve a multi-factor analysis of the dynamic cascade of complex neuropathophysiological events in the peri-lesional zone following cortical ischemia and subsequent recovery of motor function. By using this device, the NEAL lab researchers aim to investigate the use of direct electrical stimulation of the brain as an alternative therapy for improving motor recovery following stroke in the rat model.

Early treatment of stroke outcomes can help minimize damage to brain tissue and lead to a better prognosis. However, not all patients are eligible for current treatments, thus, alterative therapies are important and vital. Doctors can inject t-PA, a clot-busting drug to help dissolve obstructions and restore blood flow to brain tissue. However, it must be given within a three-hour window, or the risk will outweigh its benefits. In order to develop effective alternatives, it is important to develop a better understanding of how the brain works before and after a stroke. According to the American Stroke Association, a stroke is a type of cardiovascular disease. It occurs when either a clot blocks a blood vessel that carries oxygen and nutrients to the brain, or a blood vessel bursts. When either occurs the brain does not get the blood it needs. Brain cells begin to die because of the disruption of blood flow. But, our body needs continuous blood flow, because, as the blood circulates through our body, it brings oxygen, nutrients, and blood sugar to the cells. During a stroke, this process is disrupted.

My research apprenticeship consisted of animal experiments which were conducted in compliance with the AAALAC accredited Animal Care Committee of the University of Illinois at Chicago. Male Sprague-Dawley (SD) rats (about 350-500 g) were used in this study. I trained them to walk across a beam and assisted in surgically implanting the multi-modal device in them. During the surgery, I watched the rodents' pulse rate and oxygen saturation, and I administered a paw-pinch reflex to assure a consistent depth of anesthesia.

Movement disorders are one of the most common outcomes of a stroke. In the beam-walking task, the rats had to cross a beam that was narrowed along its size and had an under-hanging ledge. A normal rat had no problem with walking across the beam at a constant rate while keeping both of his paws on the entire part of the beam. However, a rat induced to have a stroke produced foot faults (slips) with the hind limb and moved across the beam at a slower rate. The number of foot faults indicated the motor deficit.

It took a couple of days to train rodents to maneuver across a beam. The training began after a rat felt comfortable being picked up. Every time rodents followed directions, they were rewarded with a sugar pellet. A dark box, or home cage, was placed at the end of the beam as reinforcement, and the rat stayed there for a few moments after each trial. Along each side of the beam, there were 1 cm wide ledges that increased to 2 cm as the beam became narrower. This allowed the animal to place an impaired forelimb, providing a crutch for the animal to use when there was a deficit (Figure 1). The beam was marked so that the location of the fault could be noted for each limb, at every foot.

Studying Brain Functioning with My Seventh Graders

This research apprenticeship allowed me to gain knowledge and confidence in this newly acquired knowledge regarding the nervous system, especially the triggers and outcomes of stroke in the

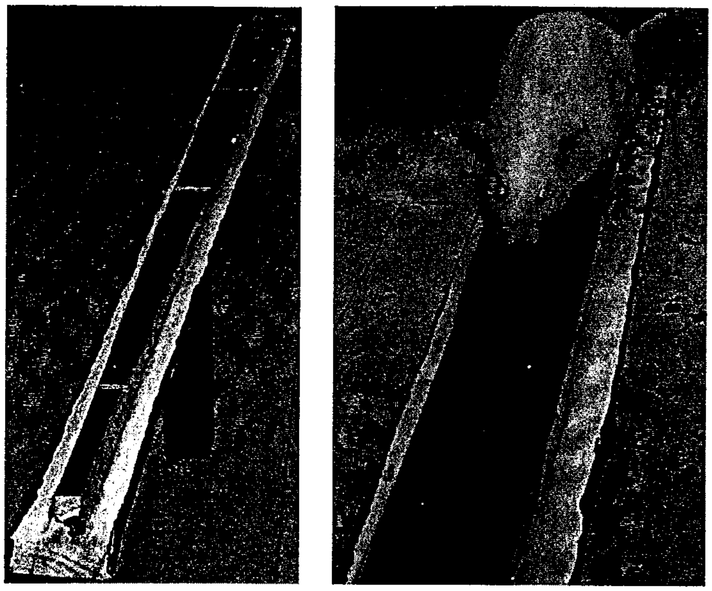


Figure 1. The beam used to assess hindlimb function and a rodent crossing the beam.

human body. Thus, I was motivated to find and use approaches to excite my students and engage them in this topic. I wanted to instill in my students the idea that in my science class we are scientists - exploring, studying, examining, modeling, understanding, finding out - like I was a scientist for a summer! The apprenticeship inspired me to find ways to emphasize connections among ideas.

Thus I embarked on creating a teaching module on one of the most extraordinary organs of our body—the brain! I put together several lessons where students get hands-on experience around the causes and outcomes of a stroke, develop their formal and informal communication skills to share scientific knowledge and understanding, and collaborate with their peers. The module is designed to help students understand the nervous system and the structure of the human brain, focusing on the cerebral, cerebellum, and brain stem regions. Below, I share briefly the module outline and offer examples of my students' work.

In the first lesson, I use a Know, Want to know, and Learned (KWL) chart entitled "Nervous System." I had students think about and write down in their journals their own ideas on the "K" and "W" parts, and then they shared with the whole class. With this information we compiled a chart together. Students asked questions such as: How large is the human brain? What is the nervous system? What is a stroke? The students' came up with more questions as the unit went on.

In the second lesson, we discuss basic brain anatomy, and students draw pictures of the brain based on what we have discussed (Figure 2). I follow this in the third lesson by showing them a visual representation of the brain and asking them to compare their drawings to the scientifically canonical picture of a brain. After discussing their

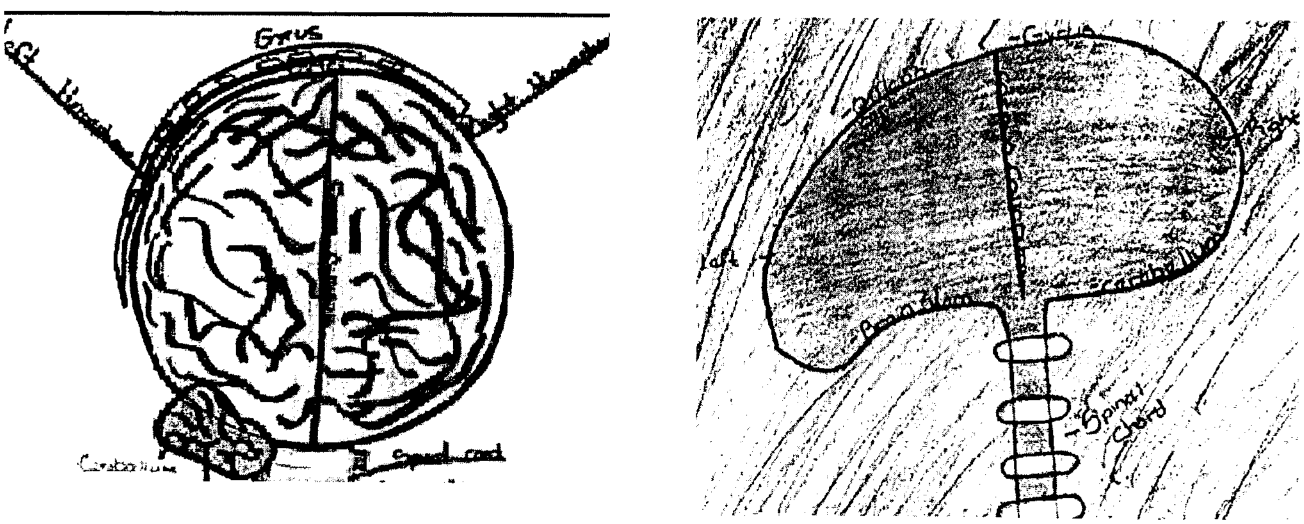


Figure 2. Examples of students' brain designs without having seen any visuals.

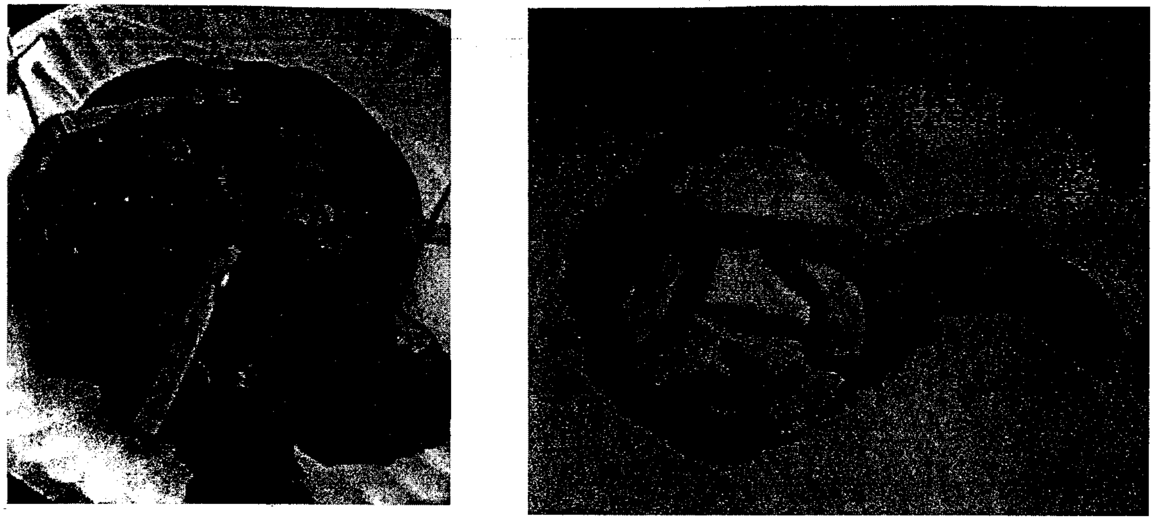


Figure 3. Two clay models of the brain produced by two student groups.

comparisons, students are asked to create a model of the brain using clay, play dough, Styrofoam, recyclables, and food. They can use different colors to indicate different structures to model a brain. The goal is to create reasonably accurate clay models featuring all of the major structures (Figure 3).

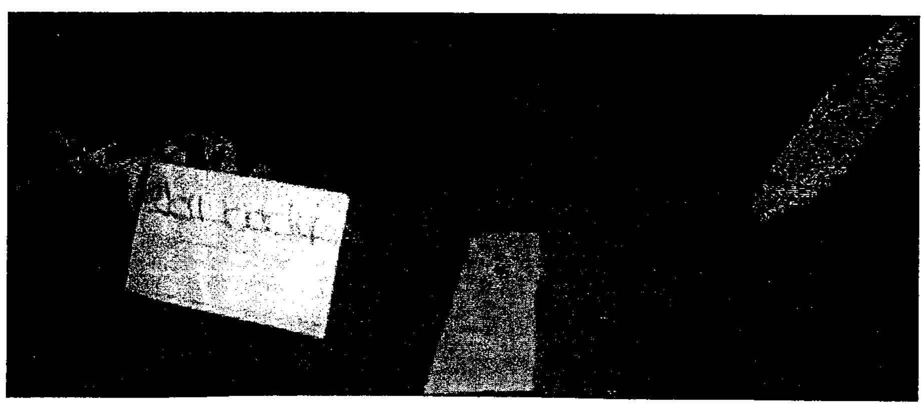
In the fourth lesson, we explore the idea that the brain performs all of its functions by receiving and sending signals through a network of fibers called nerves. Nerves are bundles of special cells called neurons. There are about 100 billion neurons in our bodies and they transmit signals. We discuss the different parts of the neuron—axon, dendrite, sheath, and cell body. This discussion is followed by students making neurons using pipe cleaners (Figure 4).

The following lessons (5-7) are used to study how neurons send messages through the nervous system to all parts of the body. The students participate in a role-playing game where they act as neurons sending signals as fast as they could. Through this drama activity, we investigate neurons, synapses, and the brain-body connection.

The following three lessons are devoted to dissecting a sheep's brain and comparing its regions to those of a human brain. While dissecting, students are able to see many of the different parts of the brain and talk and write in their journals about comparisons between human and sheep brains. Also in their journals, students write and draw their observations of the sheep brain.

We then move to two lessons that allow students to model blood vessels in the brain and simulate different types of stroke. Students recreate the "scene" of a stroke at the level of the blood vessel. They build models to explain a thrombus, embolus, and hemorrhage, using clear plastic tubing,

Figure 4. Pipe cleaner neuron.



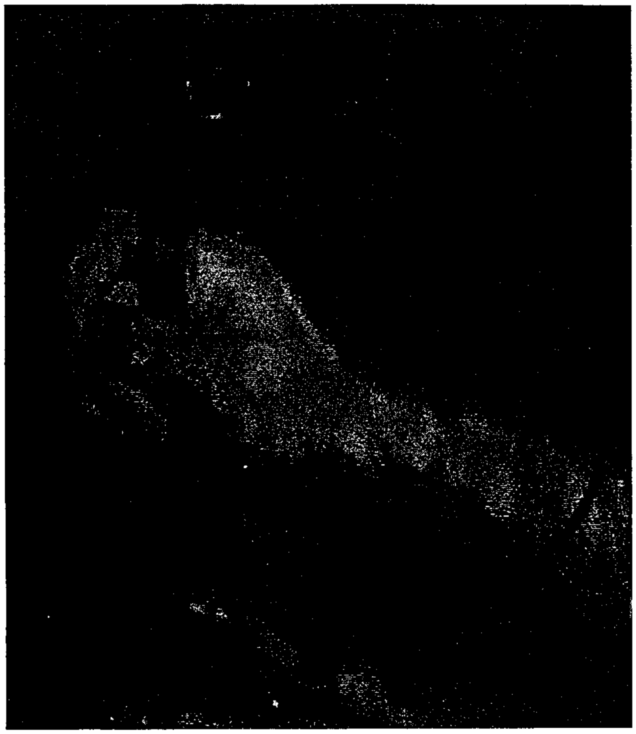


Figure 5. Healthy artery.

two containers, play dough, Red Hot cinnamon candies, and one packet of Mentos per group.

Healthy Artery Model: Students pour Red Hots through the tubing to show how they flow through easily, stimulating normal blood flow (Figure 5). In their science journals, students write what each given item represents in their bodies.

Unhealthy Artery: Students place a piece of red play dough on the inside near the end of the tubing. The amount of play dough they chose to place in the tubing is up to the group. Students think about the amount of plaque built-up in their bodies to decide how much they should use (Figure 6).

Thrombus: Students pour the Red Hots through again with the plaque already in place and explain what happens. They write in their journals what their brain will do in this situation. What does blood do when it can not get through?

Embolus: Students use a Mentos candy as an embolus and show how it will get stuck in the tube and that the blood will build up behind it.

Hemorrhage: Students cut a hole in the tube and they think about what will happen if blood is poured into that tube. Students think about what causes a hole in the blood vessels, and discuss their answers. The whole module concludes with students creating their own illustrated information book on the nervous system that they eventually share with the whole class or a peer group depending on the time available.

Concluding Thoughts

I have been teaching the human body for four years, and my weakest part has been the nervous system. I used to think that it was too complicated to teach to my seventh graders, partly because of

Figure 6. Unhealthy arteries

my lack of deep knowledge on the topic. This apprenticeship helped me develop my understanding so that I could make the nervous system meaningful to my students. In the module I briefly presented in this article, my students studied the structure of the human brain, focusing on the cerebral, cerebellum, and brain stem regions, they explored what happens to the human brain during a stroke; and they realized how the neurons communicate using electrical signals and neurotransmitters. Furthermore, my students worked together to solve problems, design models, discuss possibilities, and, thus, they experienced important aspects of scientific practice. I hope that this module was an exciting educational experience for them that can serve as a catalyst for deciding to pursue science careers. My participation in the CSTR program was definitely an exciting educational experience in my career as a middle school teacher of science.

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Useful Websites

Neuroscience For Kids:
http://faculty.washington.edu/chudler/chmodel.html
Overview of the Nervous System by NASA Quest:
http://quest.nasa.gov/neuron/background/nervsys.html
Neuroscience for Kids by Eric Chudler:
http://faculty.washington.edu/chudler/injury.html
Background Information:
http://kidshealth.org/parent/general/body_basics/brain_nervous_system.html
Activity 2: Sending a Signal
http://www.hallofhealth.org/sepa/curriculum/traumatic_brain_injuries.htm
Stroke Lesson
http://www.brainsrule.com/teachers/lesson_plans/brain_attack/hands_on_activity.htm
Sheep Dissection
http://www.hometrainingtools.com/articles/brain-dissection-project.html
More information on the CSTR program can be found on
http://vienna.bioengr.uic.edu/RET/index.html