



Exploring Neural Engineering with a Teacher-Authored Science Curriculum (Curriculum Exchange)

Kristen M Clapper Bergsman, Center for Sensorimotor Neural Engineering

Kristen Clapper Bergsman is the Pre-College Education Manager at the Center for Sensorimotor Neural Engineering at the University of Washington. She is also a doctoral student and graduate research assistant in Learning Sciences and Human Development at the University of Washington. Previously, Kristen worked as an educational consultant offering support in curriculum development and production. She received her M.Ed. in Curriculum and Instruction (Science Education) from the University of Washington.

Dr. Eric H. Chudler, University of Washington

Eric H. Chudler is a research neuroscientist interested in the neuroactive properties of medicinal plants and herbs and how the brain processes information about pain and nociception. Eric received his Ph.D. from the Department of Psychology at the University of Washington in Seattle in 1985. He has worked at the National Institutes of Health in Bethesda, MD (1986-1989) and in the Department of Neurosurgery at Massachusetts General Hospital in Boston, MA (1989-1991). He is currently a research associate professor in the Department of Bioengineering and the executive director of Center for Sensorimotor Neural Engineering. He is also a faculty member in the Department of Anesthesiology & Pain Medicine and the Graduate Program of Neurobiology and Behavior at the University of Washington. In addition to performing basic neuroscience research, Eric works with other neuroscientists and classroom teachers to develop educational materials to help K-12 students learn about the brain.

Ms. Shannon Jephson-Hernandez, Center for Sensorimotor Neural Engineering

Science educator, engineering enthusiast, and lifelong learner. Ms. Jephson-Hernandez seeks out opportunities to connect neural engineering to everything she encounters. Touching student's lives with information pertinent to their future is not only a goal but imperative. This work is her passion, as she hopes to share the importance of brain awareness to any and all within her reach. People are better prepared to make decisions when they have an awareness of the potential outcomes related to their choices. People also have an opportunity to change their futures through focusing on their neural networks and how they can modify their behavior to improve their quality of life. As students learn to design their brain through choices and habits, they gain skills to prepare them as consumers, employees and voters. Neural engineering is the best way to empower others in life changing work.

Dr. Lise Johnson, The Center for Sensorimotor Neural Engineering

Lise Johnson is the University Education Manager at the National Science Foundation funded Center for Sensorimotor Neural Engineering as well as an active researcher in the University of Washington Department of Neurological Surgery.

Mr. Michael W. Shaw, Cleveland STEM High School

Education: B.S. in Molecular and Cell Biology, University of Washington (Seattle) M.Ed in Secondary Education (Biology), University of Washington (Bothell)

I was born and raised in Los Angeles, CA, and moved to the Pacific Northwest over 20 years ago with my wife and two children. I joined the US Marine Corps Reserve in 1998 in order to help complete my education and was activated in 2003 in support of Operation Iraqi Freedom.

After 2+ decades in another career, I chose to teach in the hopes of making better use of my credentials. Teaching was the natural choice as I am passionate about providing rigorous science instruction to high school students. I currently am in my third year of teaching at Cleveland High School in Seattle, WA.

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“Traumatic Brain Injury: A Neural Network Journey” (Grades 6-12)—This teacher-authored curriculum is a product of the Research Experience for Teachers (RET) program, a summer research experience for secondary teachers at the Center for Sensorimotor Neural Engineering at the University of Washington. This engineering research center is focused on improving lives by connecting brains and technology. Research focuses on the design of a closed-loop co-adaptive bi-directional brain-computer interface which could improve the quality of life for people with specific types of spinal cord injury, Parkinson’s disease, stroke, and other neurological disorders. In this seven-week program, teachers become apprentice researchers in labs conducting cutting-edge neural engineering research. Teachers also collaboratively author curriculum materials that are inspired and informed by their experiences in the research lab.

Curriculum Unit Description—“Traumatic Brain Injury (TBI): A Neural Network Journey” is an innovative curriculum unit for grades 6-12 authored by RET participants Shannon Jephson-Hernandez (Mill Creek Middle School, Kent, WA) and Michael Shaw (Cleveland High School, Seattle, WA). During the summer of 2013, these teachers apprenticed in the research lab of Dr. William Shain within the University of Washington’s Department of Neurological Surgery. The Shain lab uses multidisciplinary approaches to enable comprehensive studies of the interactions between implanted neuroprosthetic devices and the brain.

“How can neural engineering be applied to develop solutions to issues that result from traumatic brain injury?” This essential question guides the curriculum unit. Using the Project-Based Learning model, students assume the role of neurologists, neural engineers, and journalists in order to produce a special investigative report that will inform their audience about people affected by traumatic brain injuries and the technologies that are being designed to improve their lives. The seven lesson plans apply a neural networking approach to understanding interactions within the brain on both a macroscopic and microscopic level. During the unit, students engage in web quests, research projects, hands-on investigations, lab work, video production, and presentations from guest scientists. Furthermore, students apply basic concepts of engineering and design to model building activities associated with the unit.

Highlights—This unit uses *neuroscience* in conjunction with *neural engineering* and allows students to better connect the *nature of science* research to modern day *problems* and *applications*. For example, mapping neural networks using the connections between nodes and edges provides students with the tools they need to analyze more complex networks and improves their understanding of the functionality of all networks, both natural and human-made.

Students are introduced to the central nervous system as members of an Information Journalism Team challenged to communicate to their audience information about neurological issues associated with TBI and developing technologies. They identify current research to better understand these issues and neural engineering efforts to support the needs of patients affected

by TBI. Students explore normal brain function, the impacts of brain injuries, and the potential of neural engineering devices through the use of a Brain Box model (see Figure 1). In this activity, students build a physical model of the lobes of the brain using PVC pipe and then use craft materials to construct models of the neurons within the lobes. After building the Brain Box model, students connect neurons within and across lobes and then analyze the model using what they have learned about complex networks. Once students are familiar with networking, they are better prepared to understand TBI and the treatments offered by engineered devices intended to improve the lives of those affected by TBI. Students culminate their investigation of TBI by



Figure 1. Brain box model.

predicting how the neural network will be affected by brain injuries and what the long-term effects may be depending on the specific type of injury and location of damage, all of which is made explicit by their own analysis of the Brain Box. The unit culminates with Information Journalism Teams presenting their special investigative reports about traumatic brain injuries and engineered devices.

Extensions of the unit might include having students build a working neural network with electrical enhancements intended to model action potentials, energy transfers, and transformations within the central nervous system, as well as activities that continue to expand on the engineering design process (e.g., designing 3D models of neural synapses with moving parts).

Pedagogy—Pedagogical approaches include Project-Based Learning (PBL), the BSCS 5E Instructional Model, a systems engineering approach, and development of claim, evidence, and reasoning skills. Suggestions are provided to support differentiation. Extension activities and links to digital resources are also provided. The curriculum is aligned to the Next Generation Science Standards (NGSS) and Common Core State Standards (CCSS). This unit does not include an engineering design challenge, but rather demonstrates the interdependence of science, engineering, and technology to solve problems with the human nervous system. The unit supports disciplinary core ideas in life sciences (structure and function; information processing), crosscutting concepts (systems and system models; cause and effect; structure and function; stability and change), and science and engineering practices (developing and using models; engaging in argument from evidence; obtaining, evaluating, and communicating information). The PBL curriculum model enhances the NGSS by requiring student-designed evidence of understanding to be used as the assessment. Furthermore, complementary Math and ELA Common Core State Standards identified within the NGSS are used to support science content learning.

Piloting and Revision Process—The “Traumatic Brain Injury (TBI): A Neural Network Journey” curriculum has been piloted by the teacher-authors and their colleagues with over 800 secondary students over two academic years and revised accordingly.

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