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ARTICLE
Development of an Introductory Neuroscience Teaching Experience for Undergraduates with a Low-Cost Neuroscience Summer Academy

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Undergraduate students studying neuroscience have limited opportunities to develop and apply teaching skills before joining a graduate program. Once in a graduate program, students in neuroscience programs are often hired as teaching assistants, adjuncts, or instructors of record. We propose that a low-cost, mentored, short-term summer neuroscience brain academy with high school student participants provides undergraduate students with critical introductory neuroscience teaching experience. Additionally, the experience serves as a service-learning opportunity for faculty and student personnel in a neuroscience laboratory. In this specific program, undergraduate students generate and deliver neuroscience lessons to high school students under the mentorship of a faculty member. This article contains an overview of the purpose of the summer academy, budgetary considerations, materials required, and the roles of faculty and students, with the goal that this model can be replicated at other universities. We propose that this experience addresses a critical gap in early neuroscience professional training.

Key words: undergraduate teaching; neuroscience education; neuroscience; neuropsychology; teaching; service learning

Science, Technology, Engineering, and Mathematics (STEM) graduate students often have limited teaching experience and training opportunities before they become teaching assistants (DeChenne et al., 2015). In biology departments, for example, teaching assistants can teach up to 70-90% of laboratory courses (Sundberg et al., 2005). Undergraduate lab courses are important "gateways" into science that have impacts on student retention and development (Reeves et al., 2016). Therefore, ensuring that graduate teaching assistants are properly prepared for teaching these important courses is critical to student success. The purpose of this article is to summarize an experience that provides undergraduates with teaching training prior to graduate school. In the summer of 2018, the neuroscience laboratory personnel at Tarleton State University offered the Neuroscience Brain Camp Academy to high school students ranging from 9th to 12th grades. The curriculum consisted of an introduction to neuroscience, electrophysiology, and careers in neuroscience. The academy was designed and delivered by higher education students under the advisement of a tenure track faculty member with a neuroscience specialty for the duration of one week.

Many high school neuroscience programs such as the ones hosted by the National Student Leadership Conference and Drexel University are very expensive running upwards of $2,000 to $3,495, have comparably larger funding mechanisms in place, and are typically run by faculty and graduate students (Psychology and Neuroscience, 2018 ; Neuroscience Camp for High School Students, n.d.). Our approach offers an alternative, more affordable price point for both the students and hosting university. Due to location, this program was also able to reach more rural communities, a large percentage of whose population may possess low socioeconomic status, limiting access to the neuroscience field.

BUDGET, FACILITIES, MATERIALS AND UNDERGRADUATES

Budget

The faculty mentor for the program applied for and received an Applied Learning Grant of $1500 from the Tarleton State University Center for Transformative Learning. In the first year, the majority of the costs were for equipment (described below). In the following years, lower costs will be incurred.

Facilities

The academy was created and executed in the neuroscience lab, which is a converted carpeted classroom space containing whiteboard space, cubicles, and tables. The lab has freestanding partitions. A neighboring classroom was utilized for viewing videos and computer based lessons. No specialized lab space was required. The program benefitted from the decreased activity on campus during the summer which allowed unscheduled access to neighboring classrooms.

Materials

Materials included muscle SpikerBoxes purchased from Backyard Brains (Backyard Brains, 2009), PlayDoh, and an assortment of 3D brain models. Participants were provided with a low-cost ONN ™ Virtual Reality Smartphone Headset and a copy of "The Beautiful Brain: The Drawings of Santiago Ramon y Cajal" (Newman et al., 2017). An Advanced Brain Monitoring B-Alert EEG system with electrode strips was used but was not purchased with academy funds. This optional material could be replaced by

any equipment already owned by the host lab. Office supplies included nametags, writing utensils, and journals.

Paper graduation certificates and giant microbe neuron stuffed plush toys (Giantmicrobes, Inc., Brain Cell [Neuron] Stamford, CT, USA) were supplied in a graduation ceremony. The Brainiac board game was used to entertain campers during arrival and departure times (Cat#TCG1007; Everest Toys, Ancaster, Ontario, Canada). The main university classroom used was equipped with a desktop PC and portable projector, and campers were encouraged to bring a laptop from home. Academy volunteers brought personal computers, so campers were able to participate if they did not have a laptop to bring.

Undergraduate Academy Teachers

Both undergraduate academy teachers were juniors, female (20 years old), and Caucasian. One is a Biomedical Science student and the other is a Psychology student with a minor in General Biology. Both undergraduates were either employed or volunteering in the neuroscience lab at the time, and participated in the program as volunteers. As this was an event put on by the campus' neuroscience lab, multiple graduate students also expressed interest and two were selected to help. All volunteers underwent a background check as well as trainings online, both facilitated by the university for risk management purposes. Two undergraduate students participated as program facilitators to meet the Risk Management Department's recommended instructor to camper ratio. At least three approved facilitators were required to be present at all times for the number of campers in attendance.

ACADEMY PARTICIPANT DEMOGRAPHICS

The camp participants included 8 local high school students from Stephenville, Dublin, and Bryson schools in Texas. Campers included 6 females and 2 males, ranging in age from 14-18 with a mean age of 15.9 (*SD*=1.36).

ACADEMY CURRICULUM

High schools, particularly those in low socioeconomic areas, may not have the financial stability or personnel to expose students to introductory neuroscience. By teaching participants what neuroscience is, why it is important, how to become involved in the field and the sub-fields, the academy provided an opportunity for high school students to make experience-based decisions about their academic interests and to prepare them for further study.

Schedule and Student Led Curriculum

As participants arrived each day, Brainiac (a code making and cracking board game) as well as a variety of brain models were set out so students could remain entertained until the day's activities began. Each day was ended with a raffle that allowed students to pick from a box of science toy prizes. The exception to this end-of-day routine was the very last day, when the participants engaged in a graduation ceremony and received certificates for completing the academy, a copy of "The Beautiful Brain" book (Newman et al., 2017), and a giant plush neuron.

The purpose of this academy was to provide an opportunity for undergraduates to receive introductory teaching training and experience prior to graduate school, in addition to exposing high school students to introductory neuroscience material. Undergraduates were given opportunities to teach the students neuroscience lessons covering a topic of their choosing. Each undergraduate met with the faculty mentor to discuss a lesson plan topic in advance of the academy as well as participating in a training day facilitated by the faculty member to discuss expectations and duties throughout the camp. Undergraduate students prepared lessons and presented them to the high school students along with an appropriate neuroscience related TED talk to enhance engagement. No undergraduate student put together a formal PowerPoint for their lesson, but simply displayed the multimedia they chose and led discussion. The expectation was set that the undergraduates were to practice and familiarize themselves with their assigned lesson on their own. The curriculum schedule is available in Table 1.

On day one, time was allotted for basic introductions and handing out supplies. An "Ode to the Brain" video was shown to give an initial exposure of brain facts to the

Day One
• Introductions • "Ode to the Brain" video • Discussion: What is neuroscience? • What do neuroscientists do? • How to become a neuroscientist • Faculty lesson: Action potential mechanisms • Build a neuron exercise with PlayDoh • Question and answers with current TSU students • Student-led lesson about neuroscience
Day Two
• A neuroscience problem: Pain in the brain • What is electrophysiology? • Student-led EEG demonstration • Student-led virtual reality brain tour • Student-led lesson about neuroscience
Day Three
• Introduction to primary literature discussion • Harvard Brain tour • NEURON software exploration • Student-led EMG hands-on experience • Student-led lesson about neuroscience
Day Four
• Student-led lesson about neuroscience • Homunculus mapping activity • Revisit your favorite activity • Graduation ceremony • "Ode to the Brain" video

Table 1. Curriculum Summary.

participants (Melodysheep, 2011). This was followed by a guided discussion about neuroscientists. During the discussion, student volunteers and the faculty member addressed several basic, yet crucial introductory questions such as:

- What is neuroscience?
- Why is neuroscience important?
- What do neuroscientists do?
- How does someone become a neuroscientist?
- What are the sub-fields in neuroscience?

Next, there was a faculty-led lesson about action potential mechanisms, parts of the neuron, and a basic overview of the action potential process. This provided a smooth transition to the "Build a Neuron" activity where participants used what they learned about the parts of a neuron and action potentials to create a neuron model from PlayDoh (samples are depicted in Figure 1).

To wrap up the first day, there was an open discussion between participants and TSU students. This was not a guided discussion, and there was an opportunity for participants to ask neuroscience students about their experiences at the university and working in the neuroscience lab. The day ended with a student-led lesson about neuroscience, specifically about a TED talk focusing on a new brain to computer interface using EEG that could predict what images participants were seeing (Gage, 2018).

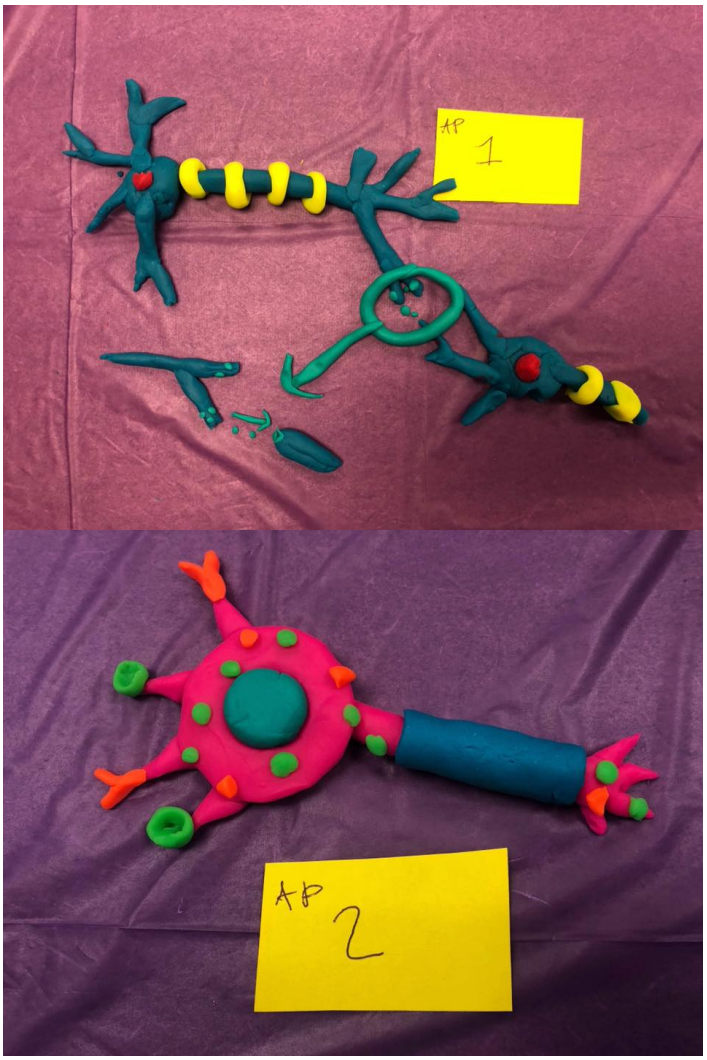

Figure 1. Samples of Participant Neuron Models.

On the second day, instructors led an open discussion on an example of a neuroscience research problem- pain in the brain. The instructors then introduced the spinothalamic tract of pain, as well as an overview of primary literature in pain. Participants were introduced to one of the research projects taking place in the neuroscience lab, as an applied example of pain research. A brief discussion of the purpose of the experiment, the methods, and the materials required was provided. The lesson transitioned into an introduction to electrophysiology including a student-led demonstration of electroencephalogram (recording). The demonstration included artifacts such as eye blinks, what the EEG records, and sample data representations. After the EEG demonstration, participants were each given their virtual reality headset. Each participant either downloaded or used a device that had the Headway Brain Explorer application (Media Maker LTD., 2017). This application was used to allow students to have an interactive, student-guided virtual reality tour of the different parts of the brain. The day ended with a student-led lesson about neuroscience, specifically the Trolley Problem, the ethical dilemma asking participants to consider if they would sacrifice one person to save five (Nelsen, 2017). The class held an engaging discussion afterwards to discuss the dilemma.

Day three began with a discussion of peer-reviewed literature and primary literature sources, how to locate them, and the sequence of steps of the peer-review process. Participants were provided with examples of peer-reviewed literature. Next, participants were introduced to NEURON software (Carnevale and Hines, 2006) and were provided with time to explore the software. Next, participants and students interacted during another electrophysiology demonstration. The Backyard Brains Muscle SpikerBox was used to display electromyography (EMG) to the participants (Backyard Brains, 2009). The day ended with a student-led lesson about neuroscience, specifically about a TED talk concerning the hallucinating brain (Sacks, 2009) featuring the famous neurologist and neuroscientist Dr. Oliver Sacks.

On the final day, an undergraduate student led a lesson about the primary somatosensory cortex. This activity allowed participants to work in pairs to generate a hands-on homunculus using a two-point discrimination task activity. provided by the Max Planck Florida for Neuroscience website (Corlew and Walker, 2019). After the students gathered these measurements, they were input into the website form to generate an interactive visualization of their homunculus. They were given a printed copy of their individual homunculus to take home with them.

Before the day ended, participants had the opportunity to revisit their favorite activity during an open discussion about future careers and plans. This allowed participants to learn more about how to pursue their varied academic interests. Before the graduation ceremony, there was a final student-led lesson about neuroscience, specifically an overview of sensation and perception. Participants were engaged with the question, "If a tree falls in a forest and there is no one

there to hear it, does it still make a sound?" After a critical discussion on the differences between sensation and perception, the students watched a TED talk about consciousness and perception and were asked to consider how sensations influence perception (Seth, 2017).

STUDENT TEACHING ASSESSMENT

As a part of an applied learning experience, each undergraduate was required to write a reflection about what was gained from the experience. The prompts asked the students to reflect upon how their current knowledge and skills within their discipline were used in the experience as well as their knowledge from courses outside of their discipline. Students were asked to write about how their experience and knowledge gained outside of their coursework played a part in the experience, to look for interconnectedness between the last three prompts (lessons learned inside your disciplines, outside your discipline, and outside of your coursework) and to elaborate on how these groups of previous knowledge came together during the academy experience. The students were asked to address how the experience impacted their global awareness and the larger impact this will have in their discipline and beyond. These prompts are meant to help the student to deeply reflect on the experience. After each student prepared the written portion, it was submitted to the mentor faculty member.

Additionally, the students were required to develop an applied artifact. This article served as the authors' artifact, providing additional professional development opportunities for the undergraduate neuroscience students in the form of manuscript preparation. Other applied artifacts included a presentation prepared for faculty members or university students; this presentation may be tailored more specifically by the Center for Transformative Learning dependent upon the context.

SERVICE LEARNING

Service learning combines the passion for service with opportunities that help to further a student's knowledge, academically and socially. Service learning can enhance knowledge of the community, increased confidence in leadership (Simons et al., 2011), and can attract more women to neuroscience (Mead and Kennedy, 2005). This neuroscience summer academy allowed students to practice exercising their leadership skills in a controlled environment where a mentor and peers were available to provide support and encouragement as needed. The high school student participants were provided with this learning opportunity to explore ideas and concepts in an environment that would not discourage them from learning or asking questions. The undergraduate volunteers helped high school students to understand a field they may potentially pursue.

Research verifies that service learning does indeed enhance the undergraduate experience. Undergraduates that were given an integrated course of classroom learning and teaching of younger students have benefitted in multiple ways (Mead and Kennedy, 2012). In a survey given to undergraduates after completing the integrated course, 91% of students reported they had a greater sense of community and 87% felt as though they were greater agents of change (Mead and Kennedy, 2012). The model provided students new experiences they would not normally encounter in the classroom and gave them a better understanding of the field they were entering.

The Tarleton State University Center for Transformative Learning focuses on providing new and unique learning and service opportunities to undergraduate students. This office provides Applied Learning Experience (A.L.E.) credits as well as funding. A.L.E. credits are the result of undergraduate students participating in or executing a pre-approved project or activity in addition to their coursework. All undergraduate volunteers received an A.L.E. credit for their contribution to the academy upon completion of criteria set by the office.

DISCUSSION

It would be beneficial to allow the undergraduate academy teachers to partake in practice sessions of their presentations prior to the actual camp dates. No specific limitations seemed to arise as a direct result of using undergraduates as facilitators but accommodating multiple personal schedules and lack of teaching experience may be considered limitations, although not specific to the use of undergraduates. The use of undergraduates was conducive to the target academy atmosphere as the instructors and facilitators were relatively close in age to the participants and were able to easily relate to the high school students. The set price of $150 per participant gave the academy enough initial capital needed for some of the initial camp supplies and equipment in the event that grant funding was not received.

In conclusion, we believe that this short-term, low-cost neuroscience summer academy for high school student participants provides undergraduate neuroscience students with a critical introduction to teaching neuroscience.

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