ARTICLE
K-12 Neuroscience Education Outreach Program: Interactive Activities for Educating Students about Neuroscience

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The University of New England's Center for Excellence in the Neurosciences has developed a successful and growing K-12 outreach program that incorporates undergraduate and graduate/professional students. The program has several goals, including raising awareness about fundamental issues in neuroscience, supplementing science education in area schools and enhancing undergraduate and graduate/professional students' academic knowledge and skill set. The outreach curriculum is centered on core neuroscience themes including: Brain Safety, Neuroanatomy, Drugs of Abuse and Addiction, Neurological and Psychiatric Disorders, and Cognition and Brain Function. For each theme, lesson plans were developed based upon interactive, small-group activities. Additionally, we've organized our themes in a "Grow-up, Grow-out" approach. Grow-up refers to returning to a common theme, increasing in complexity as we revisit students from early elementary through high school. Grow-out refers to integrating other scientific fields into our lessons, such as the chemistry of addiction, the physics of brain injury and neuronal imaging. One of the more successful components of our program is our innovative team-based model of curriculum design. By creating a team of undergraduate, graduate/professional students and faculty, we create a unique multi-level mentoring opportunity that appears to be successful in enhancing undergraduate students' skills and knowledge. Preliminary assessments suggest that undergraduates believe they are enhancing their content knowledge and professional skills through our program. Additionally, we're having a significant, short-term impact on K-12 interest in science. Overall, our program appears to be enhancing the academic experience of our undergraduates and exciting K-12 students about the brain and science in general.

Key words: outreach; neuroscience; education; STEM; K-12; neuroanatomy; drug; abuse; addiction; cognition; memory; brain injury; pharmacology; brain safety; concussion

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The University of New England (UNE) is a health science university grounded in the liberal arts with a student body of over 5,650 undergraduate, graduate/professional and online students. In 2009, four "Centers for Excellence" were formed, including the Center for Excellence in the Neurosciences (CEN). As part of the CEN's objectives, a K-12 Neuroscience Outreach Program was designed to bring together faculty, students and staff with the goal of providing engaging, interactive neuroscience lessons to students in local school systems. Key program goals include enhancing the undergraduate student experience by supplementing both their content knowledge and their professional skill set; enhancing undergraduate student recruitment and retention through participation in the program; raising awareness about neuroscience and brain safety in the community; and increasing the number of students pursuing careers in science, technology, engineering and mathematics (STEM) fields.

To achieve these goals and make a lasting impact, our program has two unique features. First, it incorporates a unique mentorship design. All of our content (organized as self-contained but complementary modules) is developed by teams of undergraduate, graduate and/or professional students, and faculty from across our five colleges. Once a "module" or lesson plan is created, it is presented to a team of our volunteers and faculty/staff leadership. Additional changes are made before field-testing the module with K-12 students. From there, a constant revision process begins. This process is designed such that undergraduate and graduate/professional student volunteers gain experience from each other and learn important lessons about the creation/revision process. In addition, our undergraduate and graduate/professional students gain knowledge about their topic and skills in presenting and summarizing information.

The second unique aspect of our program is that it is built around a "Grow-up, Grow-out" concept. Structuring education around core ideas that are repeatedly visited as a student progresses through his or her K-12 education is a main goal outlined by the National Research Council (NRC; 2012). Additionally, a key element in developing the assessments for the *Next Generation Science Standards* by the NRC is how students view the interdisciplinary nature of the STEM fields, connecting material across disciplines (2013). Our program introduces K-12 students to basic brain topics in elementary school and expands to introduce more complex topics as students reach more advanced grade levels. The goal of this vertical integration "Grow-up" design is to expose students to increasingly challenging neuroscience topics at multiple points in their

education. Integrating in related STEM topics around the central neuroscience theme constitutes the "Grow-out" portion of the curriculum and helps increase student interest in pursuing neuroscience- and STEM-related higher education and careers. Furthermore, within our "Grow-up, Grow-out" design we focus on developing hands-on, interactive activities in order to engage the students and bring the material out of the text books and into their hands. Other STEM related fields, such as engineering, are also focused on implementing an interactive, hands-on teaching style (Brophy et al., 2008; Cunningham, 2009). This pedagogical approach has been suggested to increase students' knowledge of the STEM subject being presented (Wendell and Rogers, 2013). We believe our model to approaching these goals may be helpful to other programs that are trying to establish similar outreach programs.

Over the last three years, we have seen dramatic program growth in terms of volunteers as well as K-12 students reached. In the 2010-2011 school year, the outreach program came in contact with ~500 students and in 2011-2012, over 1,500 students across 12 different events. The 2012-2013 school year saw our program expand further, reaching over 3,500 students across 31 different events. Our volunteer base also saw rapid expansion over this same time. We had 17 volunteers during the 2010-2011 school year including four undergraduates, nine medical students, two staff members, and two members of faculty. During the 2012-2013 and 2013-2014 school years our program included 91 volunteers including 45 undergraduates, 13 D.O. students, 18 Pharm.D. students, two Ph.D. students, six staff members, and seven members of faculty. Of the 91 volunteers, 48 volunteered at more than one event. This growth is the result of a concerted effort by our faculty and staff to contact school districts and teachers, work with local groups, improve our curriculum and generally have a "customer service" mentality to keep teachers engaged. Another critical piece to the success of the program has been the willingness of our undergraduate and professional students to help develop and deliver the content to the school systems.

Our program currently consists of five themes of neuroscience: brain safety, neuroanatomy, drugs of abuse and addiction, neurological and psychiatric disorders, and cognition and brain function. Initially concentrated on these neuroscientific themes, we are beginning to incorporate other fields of study, such as pharmacology, chemistry, marine science and physics into our modules. This approach to teaching neuroscience demonstrates the interdisciplinary nature of science and the importance of collaboration.

PROGRAM METHODS

Our "Grow-up, Grow-out" program begins in early elementary school, focusing on basic brain function (e.g., the five senses and the central role that the brain plays in making us aware of them) and helmet safety. As the students progress into higher-grade levels, we reintroduce the topics with more complexity as well as other

	Brain Safety	Neuroanatomy	Drugs of Abuse and Addiction	Neuological and Psychiatrics Disorders	Cognition and Brain Function
Primary School (K-3)	Read Franklin's Bicycle Helmet OR watch *Bike Safety with Bill Nye the Science Guy*	"What does your brain do?" drawing activity	-	-	Review the 5 senses Sensory tests with textures and illusions
Intermediate School (4-5)	Discuss the importance of helmets "Build-a-helmet" egg drop activity	Color the 4 lobes of the brain Build-a-neuron with pipe cleaners	-	-	Discuss learning and memory Stroop test Timed maze activity
Middle School (6-8)	Discuss signs and symptoms of concussions	Sheep brain dissection with comparative neuroanatomy	Discuss types of drugs and their effects Effects of Drugs on Daphnia activity	Introduce neurological disorders "What is a migraine?" "What is Multiple Sclerosis?" (model neurons)	Discuss short-term and long-term memory Short-term memory test activities
High School (9-12)	Melon-drop helmet demonstration Cranial Nerve examination	Human Neuroanatomy with preserved specimens	Waterwheel demonstration of dopamine depletion	"Thread-the-needle" activity "What is Alzheimer's Disease?" Telephone activity Short-term memory test	Selective attention task (Simon & Chabris, 1999) Multitasking test

Table 1. Interactive activities grouped by theme according to our "Grow-up, Grow-out" model.

increasingly advanced neuroscience topics. Within each "theme" there is a selection of activity "modules," or lesson plans, that we can take to the classrooms (Table 1).

Outlines for our most developed modules, as well as the videos used to train student volunteers, can be found on our website (http://www.une.edu/research/cen/outreach/training.cfm). Teachers can request any combination of modules and we offer flexibility with respect to the duration of each visit (usual requests are for two to four modules delivered in a 60- to 90- minute block). Students are divided into small groups, typically with no more than eight to 10 students per group. Groups then rotate through the different modules. We have designed our modules to contain enough information to last up to 60 minutes but they can be shortened to the desired length when needed by scaling down the number of activities presented. Additionally, all of our activities and lessons can be conducted within a wide range of classroom layouts without the need for specialized equipment. This ability ensures that classrooms with limited resources and equipment are able to accommodate our program with no expense to the teacher or school.

Each theme with its selection of modules is described in detail below. UNE volunteers from our undergraduate, graduate and professional programs develop and deliver the content while interacting with the K-12 students and teachers. While undergraduate students comprise the main body of volunteers, students from the College of Osteopathic Medicine and College of Pharmacy have also contributed greatly to the program. Graduate student participation enriches the program by providing an example for K-12 students of someone pursuing a career in science. This participation also enhances our multi-level mentoring by providing someone senior to the undergraduate students, while simultaneously offering a more informal, peer-like relationship to our undergraduate population that cannot be provided by faculty members. In addition, graduate students often possess advanced knowledge of one or more themes of the program, which can benefit both the K-12 students and our undergraduate student volunteers.

Brain Safety:

Following the theme of brain safety, we have developed several activities focused on concussion, traumatic brain injury, and the importance of helmet safety. This module was created in collaboration with a local foundation (www.michaelgouletfoundation.org) and undergraduate students (largely though our neuroscience club). The goal of these activities is to raise awareness of brain injury and prevention, as well as to de-stigmatize helmet wearing and encourage safe behavior during sports. For elementary school, we introduce the idea of brain safety using either a book (*Franklin's Bicycle Helmet*, Scholastic) for younger children (grade K-3) or a video (*Bike Safety with Bill Nye the Science Guy*, Disney Educational Productions) for older children (grade 4-5). The book or video is followed with a discussion period, with questions such as "What did you learn from this story?", "Why is it important to wear a helmet?", and "Does it matter how well a helmet fits?" The purpose of the discussion is to get the children thinking about why brain safety is so important and ways that they can be safer.

After discussing the importance of helmets, we engage in a hands-on egg-drop activity. Older students (grade 4-5) are divided into groups and instructed to construct helmets for eggs with materials such as plastic cups, tissues, cotton balls and tape. Students then test their final product to see if it can protect the egg from breaking when dropped from standing height. Younger students (grade K-3) observe and assist the volunteer in constructing the "helmet." The goal of this activity is to provide an exciting way for students to think critically about how helmets can protect the brain and why it is important for a helmet to fit correctly.

For students in middle and high school, the brain safety module focuses on concussions along with helmet safety. The topic is timely given the prevalence of concussions in sports and athletics and new data that indicate that repeated concussions can produce deleterious long-term effects on learning, memory and higher cognitive functions. In this module, the topic of concussions is introduced and the students are led through a discussion of the signs and symptoms of concussions (http://www.cdc.gov/concussion/pdf/athletes_Eng.pdf), including discussing the dangers of continuing to play after a suspected concussion. Students also discuss the importance of wearing a helmet. To highlight the point, students are walked through a melon drop demonstration in which a student stands on a chair and drops a melon that is not wearing a helmet and then drops a melon that is protected by a helmet. This demonstration provides a powerful visual of the effectiveness of wearing a helmet correctly in preventing brain injury. Students are also instructed on how to fit a helmet properly and when helmets should be replaced (http://www.nhtsa.gov/people/injury/pedbimot/bike/easysteppsweb/). To conclude this module, at the high school level, students are led through a cranial nerve and mini-neurological exam, demonstrating the types of tests that medical professionals can use to test brain function. The cranial nerve exam includes tests such as checking for pupil dilation and constriction, testing odor discrimination using scents such as cinnamon and coffee and using a tuning fork to test hearing and sound location.

Neuroanatomy:

A second theme of our program is neuroanatomy. This theme consists of various activities for elementary classes and two modules for middle and high school classes: sheep brain dissections and human neuroanatomy. Due to the nature of these modules, we do not bring real brain tissue to children who are below middle school grade levels, and we do not bring human brains to students below the high school level. For children in elementary school or middle school, we present plastic human brain models that we use for demonstrations similar to the human neuroanatomy module. These activities were created or adapted for our use by undergraduate students in consultation with neuroscience faculty.

In order to introduce neuroanatomy to the elementary classes, we utilize several interactive activities that explore

the basic structure and function of the brain. Students are asked to draw something that their brain helps them do and then encouraged to share with the class what they created. Next, the class is led through an exploration of basic neuroanatomy focusing on the four cortical lobes and the cerebellum. During this discussion, the role of the brain in our senses is highlighted, especially with the younger elementary classes. As we examine each lobe and its function, the students color the corresponding lobe on a basic diagram of the brain. For the older elementary classes, an introduction of neuronal structure and function follows this discussion. In order to help the students visualize the different parts of a neuron, we distribute differently colored pipe cleaners to the students and walk them through constructing a neuron using the pipe cleaners (Brain Awareness Council, Wake Forest University Graduate School of Arts and Sciences). This activity is informative and the students create something that they can take home.

For the middle and high school classes, we offer guided sheep brain dissections to explore neuroanatomy. The sheep brain dissection focuses on comparative neuroanatomy while allowing students to participate in a hands-on dissection. Along with the sheep brains and dissection tools, we distribute several mouse and rat brain specimens and human brain models, asking students to compare the characteristics of the brains. This opening question can lead into discussions of brain morphology (overall size, presence of gyri and sulci, anatomical features, etc.). We then focus specifically on the sheep brain, beginning with a discussion of the lobes and structures that are visible on the outside of the brain, then dissecting the brain to view interior structures and tissues such as the hypothalamus, thalamus, white and gray matter, ventricles, and corpus callosum. The discussion may also include neuronal anatomy, nerves, and neuronal signaling in order to explore the cells that create the structures being dissected. The dissection typically consists of removal of the outer meninges, followed by one mid-sagittal cross section and a coronal section of one hemisphere. Students are guided through the dissection by volunteers who lead the discussion but allow students to perform the dissection themselves, providing them with a hands-on experience. Dissections are typically performed in groups of 3-4 students per sheep brain.

Another module that we use to explore neuroanatomy is an in-depth discussion of brain anatomy while observing human brain specimens. The goal of the human neuroanatomy module is to introduce students to the structures and functions of the human brain. We present this module using two preserved human brains, one whole and one sagittally dissected. We only present the human brains to high school students. However, if middle school classes wish to have the neuroanatomy module, we can also discuss the material using plastic human brain models. Using brain specimens, students observe the various aspects of the human brain such as the four lobes and other brain structures. Along with this discussion of the functions of the brain structures, students also explore the functions of a neuron and how diseases or disorders, such as stroke or alcoholism, can disrupt function of the brain. Introducing the concept of neurological disorders with the discussion of anatomy encourages students to think about the relationship between brain structure, function and human behavior.

Drugs of Abuse and Addiction:

Our newest theme focuses on the neurobiology of drugs of abuse and addiction. Presented to middle and high school students, this theme is centered on educating students about the effects of drug use and the biology of addiction. The modules created for this theme were developed in collaboration with a psychopharmacologist and pharmacy students. In addition, the dose-response curves for the Daphnia activity were created as part of a classroom-laboratory experience in our Introduction to Neuroscience course. The purpose of these modules is not necessarily to moralize the use of psychoactive drugs, but to educate students about the impact of drug use on the brain.

Students begin with a general discussion of the different types of drugs (i.e., stimulants, depressants, hallucinogens). Following this introduction, we demonstrate the effects of drugs using an interactive activity (explained in detail below). After conducting these activities, students have the opportunity to ask questions about drugs and addiction. We believe that by providing the students with the opportunity to ask questions about drugs, we can provide them with accurate information while removing some of the stigma surrounding discussions of drug use.

Waterwheel activity: One activity that we have developed for this module demonstrates the dopamine-depletion hypothesis with a waterwheel. The waterwheel (R.B. Manufacturing #302484) has an indicator strip of lights that increases and decreases in intensity when the rotation speed of the wheel increases and decreases, respectively. Although designed for use with water, we have a volunteer spin the wheel by hand. The wheel is spun at a steady speed to indicate regular brain activity. As the effects of drugs on dopamine levels are explained, the wheel is spun faster to indicate a surge of dopamine. At some point, the wheel is slowed down and the resulting lack of light is compared to the lack of dopamine following a simulated binge of a stimulant (e.g., methamphetamine or cocaine). The light indicator strip of the wheel helps the students to visualize the dopamine levels as our volunteers explore the process.

Daphnia activity: Another activity that we have incorporated into this module is a kit that helps the students explore the effects of common drugs on an organism. Using *Daphnia* as a model organism, this kit (Carolina Biological Supply, item #841160) contains several drugs (e.g., caffeine, alcohol, nicotine, adrenalin, etc.) that can be introduced to the *Daphnia* environment. Students isolate individual *Daphnia* on a microscope slide, add a chemical to the environment, and observe changes in the heart rate and overall behaviors of the organism.

Neurological and Psychiatric Disorders:
This theme focuses on introducing neurological disorders and how they can occur by reviewing symptoms and possible causes of three commonly encountered disorders. Volunteer undergraduate students, in consultation with a neuroscience faculty member, created this module. To begin, students are introduced to the concept of a psychiatric/neurological disorder and provided examples that range from mood disorders, such as bipolar disorder or depression, to neurological disorders such as epilepsy or Parkinson's disease. After a general discussion of neurological disorders as a problem within the nervous system at a molecular, cellular or system-wide level, the discussion focuses on three specific disorders. The first disorder discussed is headache/migraine, which students are typically familiar with given its prevalence. Students examine the signs and symptoms of migraines, along with discussing stimuli that can trigger migraines and techniques to help prevent them.

Following this discussion, the second disorder, multiple sclerosis (MS), is introduced. Typically, fewer students are familiar with MS than migraines because it is less common. As before, the students explore the prevalence and common symptoms of MS, including a visualization of the neuronal scarring that occurs in MS using two model neurons, one of which represents a typical neuron and one of which represents a MS-affected neuron. Both models were constructed with a rubber bulb (cell body) and rubber coated wiring (axon). These models introduce the basic concept of neuronal signaling and demonstrate how MS interferes with this process. A hands-on activity is used to demonstrate fine-motor impairment, a common symptom of MS. For this demonstration, two students wear winter gloves (one very thick pair, one moderately thick pair) and one student does not wear any gloves. Students are timed as they attempt to pick up a needle and thread and subsequently thread the needle. While this is a fun competition for students, it also is designed to convey some of the difficulties faced by people diagnosed with MS.

The third neurological disorder discussed in this module is Alzheimer's disease. Once again, volunteers lead a discussion of the prevalence, symptoms and possible etiology. Students are familiar with Alzheimer's disease and many know someone who is afflicted. The "telephone" game can be used to demonstrate how neuronal messages can be disrupted by poor transmission between neurons. In this game, students form a circle, usually with at least one volunteer joining, and a student begins by whispering a sentence to a student beside them (e.g., "neurons help us move"). The message is then passed around the circle, whispered from one student to the next. The last student in the circle announces what he or she heard and the first student reveals the original message. If a volunteer is participating in the game, he or she can subtly alter the message (e.g., "nerds hit the groove"). In addition, we can illustrate cognitive impairments using a short-term memory task. The students are split into two groups and given a list of numbers to memorize. One group is then distracted by being engaged in conversation. Typically the undisturbed group performs better, with the distracted group modeling the effects of Alzheimer's disease.

Cognition and Brain Function:
The final theme of our program explores the higher order functions of the human brain, specifically learning and attention. Undergraduate student volunteers, in consultation with a neuroscience faculty member, created this module. For this theme, we have developed specific activities tailored to different grade levels. When visiting early elementary classes (grade K-3), we focus on very basic human neuroanatomy and function (e.g., different parts of the brain work together to help us do things), as well as brainstorming about the myriad things that require the brain (i.e., almost everything). The neuroanatomy presented is typically limited to the lobes of the brain, emphasizing one or two familiar functions with each lobe. While we do not expect the younger students to remember the names of brain regions, our focus is to demonstrate that the brain is important in almost all bodily functions and sensations. Some activities demonstrate that the senses inform the brain and the brain can inform the senses. Students are asked to feel different textures without looking at what they are feeling (e.g., cotton balls, aluminum foil balls) as well as view ambiguous images and determine what the image is showing (e.g., the duck-rabbit image, the Rubin vase). Older elementary classes (grade 4-5) explore the lobes of the brain and their functions in more depth. To examine other aspects of brain function with the older elementary students, we use interactive activities such as the Stroop test and timed repetitive mazes. By having the students solve a maze multiple times, we demonstrate the importance of practice and the ability of the brain to learn information through repetition. Using different colored pipe cleaners for different parts in constructing a neuron, students discover the names and functions of neuronal structures in a simple and informative hands-on activity.

When visiting middle and high school classes, our focus for this module is less on neuroanatomy and more on the higher order functions of the brain. We begin by discussing short-term and long-term memory, the regions associated with the two types of memory, and tools to improve one's ability to remember information. Some of these tools include mnemonic devices such as "chunking" and method of loci. Chunking is the process of organizing information into familiar units (Myers, 2010, p. 333-334). Method of loci is a device in which a series of objects or ideas are associated with a familiar setting, usually a room, and hence in visualizing the room and the associations made, the recall of the objects or ideas is greatly facilitated (Bolt, 2010). The importance of sleep in learning and memory is also emphasized. The students are asked to report how many hours of sleep they got the previous night. After the students participate in the memory activities, their results are grouped by hours of sleep and the effects of sleep on memory performance are discussed. Adequate sleep tends to result in better memory performance, though results will vary from group to group.

After discussing memory and the importance of sleep,

students are led through activities focused on attention and multitasking. An engaging activity that the students enjoy introduces the topic of selective attention. This activity is the only one that we present from any theme that requires a computer. The students view a video developed by Simons and Chabris (1999) to highlight selective attention (http://www.youtube.com/watch?v=vJG698U2Mvo). The video shows two groups of people bouncing a ball between them. People wearing white clothes pass to others wearing white, and those wearing black clothes pass to others wearing black. Students are asked to count the number of passes made by the white team. While the teams are passing the ball and moving around the stage, a person in a gorilla costume passes through the teams and bangs its chest. The purpose of the video is not the number of passes made, but whether the students notice the gorilla. We have found that preparing the students prior to showing the video by emphasizing that an accurate count of the number of basketball bounces is important and absolute silence is needed produces the best results. After watching the video, students learn about selective attention and "missing the gorilla." For example, if students are not paying attention in class by passing notes, using cell phones, etc., it is easy to miss information presented by the teacher.

Following the Simons and Chabris video, students discuss multitasking and conduct activities demonstrating its effects on productivity. Students are asked to draw three lines on a piece of paper. On the first line, volunteers instruct the students to write the sentence "Multitasking is worse than a lie," and on the second line, the numbers 1 to 27. Students are timed and asked to write down how long they took to complete the task. After the students are finished, volunteers then ask the students to use the third line they drew on their paper to write the sentence and the numbers 1 to 27 again at the same time, alternating between the two (i.e. "M1u2l3t4i5t6a7s8k9i10n11g12i13..."). Students typically take much longer (usually more than twice their first time) to complete this second task. Students then discuss why completing each sentence individually is easier than attempting to complete them simultaneously.

ASSESSMENTS

We are still in the naissance of assessing different parts of our outreach program. Nevertheless, we have conducted multiple surveys in order to measure the impact of the program on our volunteers as well as the classrooms we visit. A recent survey of our volunteers focused on the perceived impact of the program on their scientific knowledge as well as the development of professional skills, such as public speaking and conveying scientific ideas and concepts to the lay public. Volunteers who participated in visits during the 2013-2014 and 2012-2013 school years were asked to complete a brief survey (Appendix A). Our survey had an undergraduate response

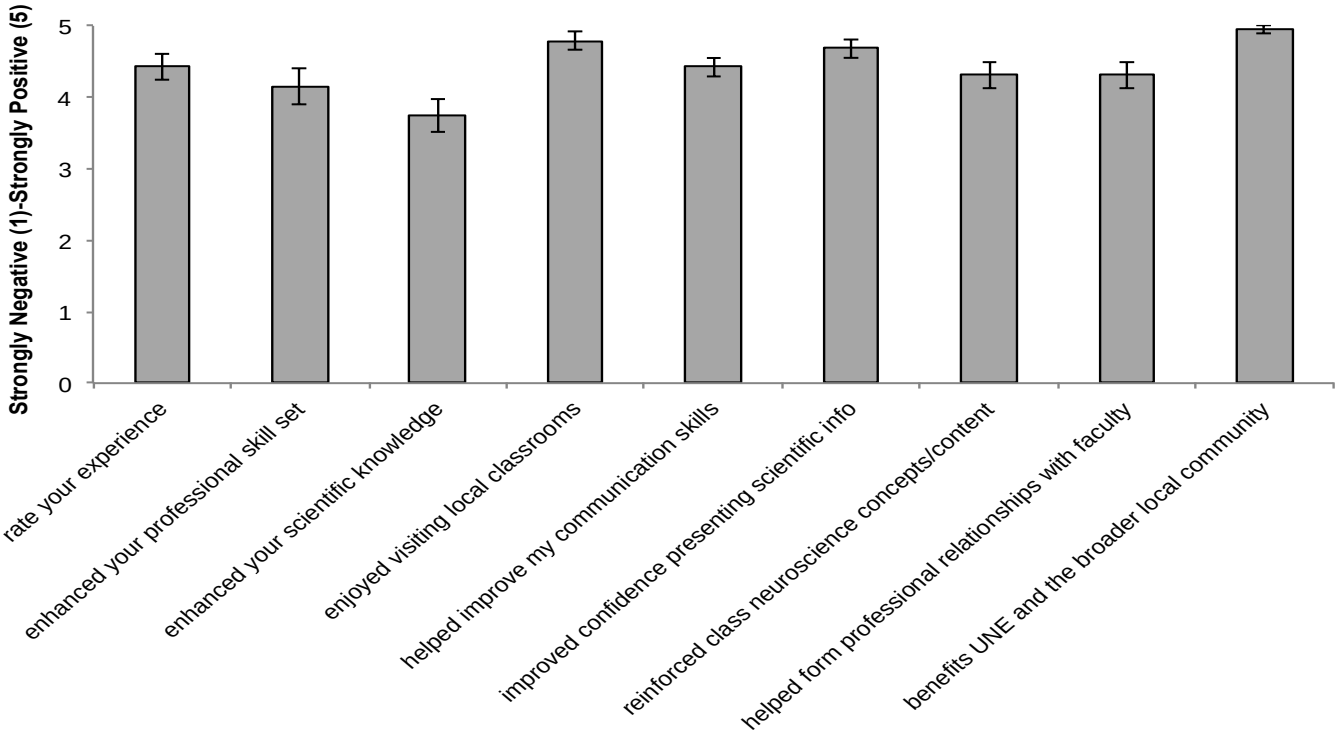

Figure 1. Undergraduate results from a survey of volunteers. Average responses from undergraduate students asked a series of questions regarding the impact of their participation in the outreach program on various aspects such as communication skills, scientific knowledge, faculty relationships, and their overall experience. n=19.

rate of 42% and an overall response rate of 48%.

Volunteers were asked to rate different aspects of the program and how those aspects impacted their undergraduate experience on a scale of 1 to 5, with 1 being the extreme negative response and 5 being the extreme positive response (Fig. 1). With an average response of 4.42, a majority of undergraduates rated their overall experience with the program as either above average or excellent (84%) and no respondents rating their experience as below average or poor. Most undergraduates also indicated that the program enhanced their scientific knowledge (89%) with an average response of 3.74. Almost all undergraduate volunteers surveyed agreed or strongly agreed that the program helped connect them with university faculty and form professional relationships outside of the classroom (89%) with an average response of 4.32. The same number of undergraduates (95%) agreed or strongly agreed that their communication skills were improved with an average response of 4.42 and that the program gave them more confidence in presenting scientific information to younger students with an average response of 4.68. All volunteers who completed the survey said that the program is a benefit to the university and the broader local community with an average response of 4.95 and they would recommend the program to a friend.

In addition, using admissions and registrar information, we have also assessed the impact of our program on undergraduate student retention. Historically, UNE's retention rate after one year is 66-88% and has a 5- and 6-year graduation rate of 47-60%. In the two years of data we examined our program, we averaged greater than 96% retention rate for students returning to the university or graduating, suggesting that our program is associated with satisfied students.

We also surveyed students who took part in activities presented by our program in their classroom in order to assess the impact of our ability to expose and cultivate an interest in science and the pursuit of STEM careers in K-12 students. To accomplish this, an assessment tool was created from an existing scale, termed "My Attitudes Towards Science" (MATS), developed by Hillman et al. (2013). Survey questions focused on the students' feelings towards science, the importance of science, science as a career, and the importance of helmet safety. Teachers administer the brief questionnaire (Appendix B) to the students approximately one week before the visit. Program volunteers then administer it again at the end of our visit (Fig. 2). Our data reflects the opinions of 138 students in grades 6- 12 from seven different classrooms.

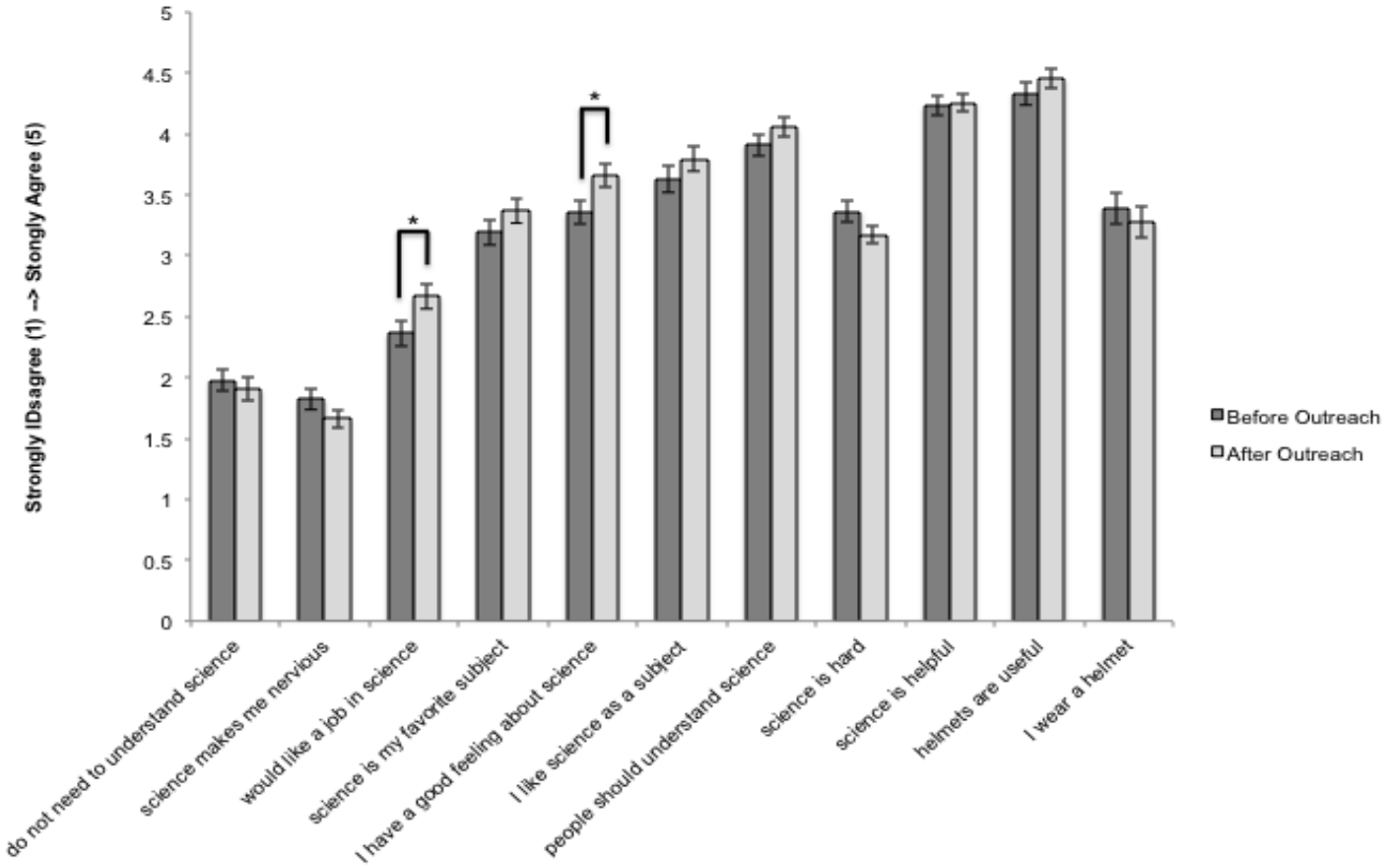

Figure 2. Results from the My Attitudes Towards Science (MATS) survey. Average responses from middle and high school students to the MATS survey, consisting of 11 questions focused on students' attitudes and feelings towards science and helmet safety, administered approximately one week prior to our visit and immediately after our visit. n=138 students

Our questionnaire shows significant, if modest, improvement in general feelings towards science and students who would like a job in a scientific field. These data also show that there were no decreases in students' attitudes towards science. In addition, attitude toward helmet use and recognizing the importance of wearing helmets is another important goal of our program. Though our results do not show significant improvement in students' feelings towards the importance of helmets and their use, the baseline of students who believe helmets are useful was high and remained high. Going forward, it will be important for us to collect longitudinal data on our effectiveness as well as surveying students in younger grades.

COMMUNITY INVOLVEMENT

In addition to visiting classrooms, we have found working with other non-profit groups to be beneficial in terms of building cohesion around public health issues and as a source of ideas, materials and contacts. First, we have partnered with a local brain injury prevention foundation, The Michael T. Goulet Foundation (http://www.michaelgouletfoundation.org/), which focuses on brain injury and helmet safety. Our program receives grants from this group and works with them on helmet giveaways, contests, content creation and outreach events. We have held numerous helmet giveaways and helmet safety demonstrations. In addition, we have sought national partners, including the Dana Alliance for Brain Initiatives (http://www.dana.org/danaalliances/), which provides support for our program in the form of materials and equipment.

Our program has also partnered with local businesses and artists to raise neuroscience awareness through other venues. A recent event in partnership with a local gallery (http://feedtheengine.org/) showcased artists who suffered from chronic pain and other artwork depicting chronic pain. This installment at a local art gallery brought to light the pain that some individuals endure continually and helped to educate the public about the symptoms and consequences of chronic pain. Efforts like this also tie back into our neuroscience modules (e.g., the addiction module and the current epidemic of prescription opioid abuse).

FUTURE PLANS

In addition to efforts in expanding our module content and geographic reach, we are currently developing a summer workshop for high school teachers. The goals of this summer workshop are to aid teachers in incorporating science, specifically neuroscience, into their curricula and thereby also developing a relationship with the teachers. By teaching K-12 professionals to incorporate neuroscience into their curricula, we aim to increase the amount of neuroscience taught in the classroom throughout the school year. We also strive to develop and cultivate relationships with the teachers in order to expand the reach of our program in both geographic area and the number of school visits and revisits.

CONCLUSION

The UNE CEN outreach program is making a positive impact in the education of undergraduate students, making progress in raising neuroscience and brain awareness in local communities, providing support to local schools to enhance STEM education, and developing and cultivating ties between UNE and the surrounding communities. Our program utilizes a team-based approach incorporating undergraduate and graduate/professional students as well as faculty and staff. It is built around a "Grow-up, Grow-out" design focusing on five main themes: brain safety, neuroanatomy, drugs of abuse and addiction, neurological and psychiatric disorders, and cognition and brain function. We have developed interactive modules and activities that can be modified to fit different grade levels and do not require any special classroom equipment. Our volunteers visit local classrooms to present neuroscience-oriented material that increases in complexity as we revisit students as they progress from elementary school through high school.

The outreach efforts have increased the total number of students engaged each year, with a count of 3,500 students for the past 2012-2013 school year. We are assessing how our program impacts our volunteers as well as K-12 students. A survey of our undergraduate volunteers revealed the program is having a positive impact on many aspects of the undergraduate experience including communication skills, scientific knowledge, and forming professional relationships with university faculty outside of the classroom. Our program used a different metric, termed the MATS scale, to assess our impact on K-12 students. Current MATS results show a significant increase in students' general feelings towards science and students who would like a job in a scientific field. Our survey also showed no significant decrease in students' attitudes towards science.

We have partnered with local businesses, artists, and nonprofit organizations in order to reach students outside of the classroom as well as the general public. Currently, our program is growing to include a summer workshop developed for local teachers designed to help them incorporate neuroscience into their curricula.

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Appendix A

CEN Outreach Volunteer Survey

1. What year were you in when you volunteered with the CEN K-12 Neuroscience Education Outreach Program?

- Undergraduate 1st year
- Undergraduate 2nd year
- Undergraduate 3rd year
- Undergraduate 4th year
- Professional student
- Graduate student

2. How would you rate your experience with the CEN K-12 Neuroscience Education Outreach Program?

Poor	Below Average	Average	Above Average	Excellent

3. How has your experience visiting local classrooms with the CEN K-12 Neuroscience Education Outreach Program enhanced your professional skill set?

No impact	Somewhat enhanced	Enhanced	Moderately Enhanced	Greatly enhanced

4. How has your experience visiting local classrooms with the CEN K-12 Neuroscience Education Outreach Program enhanced your scientific knowledge?

No impact	Somewhat enhanced	Enhanced	Moderately Enhanced	Greatly enhanced

5. How would you rate how much you enjoyed your experience visiting local classrooms with the CEN K-12 Neuroscience Education Outreach Program?

Did not enjoy	Somewhat did not enjoy	Enjoyed	Moderately enjoyed	Greatly enjoyed

Did not enjoy	Somewhat did not enjoy	Enjoyed	Moderately enjoyed	Greatly enjoyed

6. The CEN K-12 Neuroscience Education Program...

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
a. Helped improve my communication skills.					
b. Gave me more confidence in presenting scientific information to students in a K-12 setting.					
c. Reinforced neuroscience concepts and content that I learned in my classes.					
d. Helped connect me with UNE faculty and form professional relationships outside of the classroom.					
e. Is a benefit to UNE and the broader southern Maine community.					

7. I would recommend the CEN K-12 Neuroscience Education Outreach Program to a friend.

If no, please explain why.

8. What was the best part of the outreach experience for you?

9. In what ways could the program improve?

10. Please provide any additional comments about your experience with the CEN K-12 Neuroscience Education Outreach Program.

Done

Appendix B

My attitudes towards science

Gender: O Male O Female

Read each sentence. Decide if you disagree a lot, disagree a little, have not decided, agree a little, or agree a lot. Mark which answer is the one that shows how you feel.

Disagree a lot=1; Disagree a little=2; Have not decided=3; Agree a little=4; Agree a lot=5

1. People do not need to understand science because it does not affect their lives.	1	2	3	4	5
	1=Disagree a lot				5=agree a lot
2. It makes me nervous to even think about being in a science class.	1	2	3	4	5
	1=Disagree a lot				5=agree a lot
3. I would like a job as a scientist.	1	2	3	4	5
	1=Disagree a lot				5=agree a lot
4. Science is one of my favorite subjects.	1	2	3	4	5
	1=Disagree a lot				5=agree a lot
5. I have a good feeling toward science.	1	2	3	4	5
	1=Disagree a lot				5=agree a lot
6. I like science classes.	1	2	3	4	5
	1=Disagree a lot				5=agree a lot
7. People should understand science since it is an important part of their lives.	1	2	3	4	5
	1=Disagree a lot				5=agree a lot
8. Science is hard for most students to understand.	1	2	3	4	5
	1=Disagree a lot				5=agree a lot
9. Science is helpful to understand the world.	1	2	3	4	5
	1=Disagree a lot				5=agree a lot
10. Helmets are useful, effective and necessary for keeping my head and brain protected.	1	2	3	4	5
	1=Disagree a lot				5=agree a lot
11. I wear a helmet when I ride my bike or do other activities (skateboarding, skiing, snowboarding, riding ATVs or snowmobiles, etc.).	1	2	3	4	5
	1=Disagree a lot				5=agree a lot