INTRODUCTION
The United States education system is significantly underperforming compared to other countries, specifically in STEM (science, technology, engineering, math) fields. According to data collected by the U.S. Department of Education, about 10 percent of U.S. middle school students will pass the international science aptitude test TIMSS, where 25 percent of students in China and 32 percent of students in Singapore will pass [8]. In mathematics, 75 percent of U.S. middle school and high school students are behind and will graduate without being proficient in the subject [8]. Furthermore, a third of all middle school math and science teachers are not certified to teach in their respective subjects [7]. These problems, among others in the education system, lead to low high school and college graduation rates. Approximately 1.1 million U.S. high school students drop out of school annually and only 46 percent of students finish college [9]. The federal government has allotted $170 million towards better teaching STEM curriculum in middle schools and high schools [6].

The University of Pittsburgh holds a Bioengineering Summer Camp for middle school and high school students every year, promoting an interest in STEM fields and teaching science and engineering concepts. The overall goal of the camp is to begin teaching basic biology, chemistry, and engineering early and with hands-on activities, so that students will be better prepared in upper level high school and college classes. This will increase standardized test scores and graduation rates. The camp is set up in three one-week sessions, with new students at each session, so that almost eighty students can participate per year. The camp is organized in modules that each last one to one and a half hours long. A module consists of a lecture about the science or engineering topic and then an activity or experiment that the students perform themselves. Modules of this past year included a knee dissection and repair of the pericardium, building and controlling a robotic hand, tissue regeneration scaffolds, and teaches students proper repair, teaches students about the importance of porosity in nerve guides and regrowth of nerves under ideal conditions including proper biodegradability, growth factor absorption, and porosity [2]. Porosity is very important in regeneration because the nerve guide must be porous enough to allow growth factors and nutrients in so that the nerve will grow. However, it must not be so porous that it is too weak and collapses under the weight of water and the regrowing nerve.

OBJECTIVE
The objective of this internship is to develop and execute a module at the bioengineering summer camp that teaches students about the nervous system and nerve damage and repair, teaches students about the importance of porosity in tissue regeneration scaffolds, and teaches students proper laboratory skills and cell culture technique.

SUCCESS CRITERIA
This module will be successful if the students: learn the basics of the nervous system including anatomy of a neuron and nerve, the action potential, synapsing, nerve damage and repair, and porosity; are able to successfully build a nerve guide and plate cells onto it, which has a time limit of one hour; are able to kill and dye the cells after three days; are able to observe and count the cells and see differentiation, which has a time limit of half an hour; and are able to observe how porosity affected cell growth. Finally, this internship must cost less than $1,000 to perform.

METHOD
Before the camp started, a nerve guide protocol was tested and salt levels, which affect porosity, were changed in order to develop the best module for students to participate in. Three different porosity levels (70 percent, 80 percent, 90 percent) were determined from these changes.

During the camp, students were first given a lecture on the nervous system including anatomy of a neuron and nerve, action potential, synapsing, nerve injuries, and nerve repair. The idea of porosity in a nerve guide was proposed and each student hypothesized how porosity would affect cell growth based on the lecture. The module was set up to allow students to make a hypothesis about which porosity (70 percent, 80 percent, 90 percent) would result in the most cell growth and differentiation, and then test that hypothesis, while still allowing them to learn the laboratory skills and cell culture techniques. Next, students each built their own nerve guide using the following protocol from Dr. Kacey Marra’s Adipose Stem Cell Laboratory [2]: 8.5 g of poly vinyl alcohol was added to 50 mL of phosphate buffered saline and a capillary tube was dipped in and then allowed to dry. Next, 1.30 g of polycapro lactone was added to 15 mL of ethyl acetate, stirred and then added to NaCl, which varied depending on porosity. The capillary tube was dipped in this mixture five to six times.
with 5 minutes in between to dry. Finally, the capillary tubes were placed in deionized water so that the nerve guide could be easily removed. Students then plated neural stem cells onto the nerve guides using 4 mL of media (Dulbecco’s Modified Eagle Medium, fetal bovine serum, penicillin-streptomycin) they mixed in a previous module. After three days, the cells were killed using 3 mL of 100 percent ice-cold ethanol and dyed using 3 mL of toluidine blue stain. Students used microscopes to observe and count stem cells and differentiated cells with 1 mm². The counts were approximated and compared to each other during a group discussion and then students were tested on information they learned in the lecture and during the experiment with a group worksheet.

**RESULTS**

Students who built 70 percent porous nerve guides counted approximately 100 stem cells per mm². Students who built 80 percent porous nerve guides counted approximately 200 stem cells per mm². Finally, students who built 90 percent nerve guides counted approximately 50 stem cells per mm². Most students were not able to observe differentiated cells on the nerve guides and so those totals were not counted.

The group worksheet grades were very high, with all groups getting at least a 90 percent and the highest grade being a 100 percent.

**DISCUSSION**

The objective of this internship was to build a module that would teach students about the nervous system, porosity, and laboratory skills and cell culture. This objective was successful based on the final results of the module. Students were able to learn about the nervous system and answer questions about it on a worksheet after three days, showing that they did understand and remember it. Students were also able to make a hypothesis about how porosity would affect cell growth based on the lecture, which porosity would be most effective, and then test that hypothesis. After three days, students were able to kill and dye the cells and then observe them under a microscope. They were also able to count cells and then discuss why the 80 percent porous nerve guides had the most cell growth, showing that they understood the concept of porosity. However, students were not able to observe differentiated cells. This step of the module was unsuccessful.

Because of the students’ ages and education levels, there were some limitations to the project. For many of the students, especially those in middle school, this was their first time performing any laboratory work and cell culture. Because of this, they could have easily made mistakes in technique such as measuring, or not allowing enough time for stirring, drying, etc. There could also have been mistakes during the cell culture such as forgetting to use sterile equipment or adding the wrong amount of media, fetal bovine serum, or penicillin-streptomycin. This could be the reason students were not able to observe differentiated cells.

There are many opportunities for this camp in the future to continue developing interest in science and engineering in middle school and high school students, and to continue teaching these topics early and with hands-on activities. Hopefully the camp can expand to include more students and sessions that are longer than one week. This will only give the students more opportunities to explore the different topics of bioengineering, and would give mentors more time to run their modules, which seemed rushed at some points during the camp. Depending on funding, the camp could also travel to different parts of the country, like it has in past years. This camp can also expand based on new technologies that are being researched and developed. Because only a few of the modules are recycled annually, there is a lot of room to grow and progress. All of these ideas are heavily dependent on funding, but with such a need for better STEM education, hopefully funding will be found and as many students as possible can learn.

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**REFERENCES**
