INTRODUCTION

Previous research has clearly shown that studying a curriculum related to science, technology, engineering, and math (STEM) has numerous positive effects on students. These effects include increased motivation to learn, trends of higher achievement, and positive attitudes toward school [1]. Also, studying STEM topics makes students better problem solvers, better innovators and inventors, logical thinkers, and technologically literate [1].

Although the benefits of exploring STEM are clear, STEM education is underemphasized in classrooms across the United States. In 2006, 15-year-olds in the 90th percentile, the top tier high school students in the United States, scored below 29 other countries in mathematics and 12 other countries in science [2]. In 2007, only six percent of eighth grade students in the United States qualified in the advanced benchmark for mathematics in the Trends in International Mathematics and Science Study [2]. These scores were considerably lower than competitor countries, such as Korea, Singapore, and Taiwan, where 40 to 45 percent of students were distinguished as advanced [2].

Recognizing the necessity for reform in curriculum, PTEI presented students an alternative method to explore STEM topics frequently neglected in the classroom setting. These topics were introduced through the PTEI summer camp, a five day program for middle school and high school students. As a result of their participation with the PTEI summer camp, students gained knowledge and experience of advanced tissue engineering topics, used new lab equipment in high level procedures, and worked with college professors, high school teachers, undergraduate students, and peers in an interactive, hands-on learning environment.

The goal of the camp was to increase middle school and high school students’ understanding of and experience with tissue engineering, while increasing their interest in STEM and higher education. PTEI also aimed to expose the students to experiences that are unavailable to them in their classrooms. The success criteria was that following participation in the PTEI summer camp, students would exhibit an improved knowledge of tissue engineering as well as an increased interest in science, specifically bioengineering, and higher education.

METHODS

Several steps of preparation were required prior to the PTEI summer camp. It was essential that the preparation process begin by selecting and designing the various camp modules. Each module incorporated into the camp was a hands-on learning activity that emphasized a specific tissue engineering topic. Ultimately, the roster of modules consisted of many activities that PTEI utilized in previous summer camps with high success rates, as well as the introduction of several new modules. The new modules related to cardiovascular tissue engineering and were designed by the PTEI undergraduate interns. Each intern was responsible for designing and implementing his/her own module. A specific example of an activity designed by an intern was the module entitled “Monitoring Daphnia Magna Heart Rate.”

Prior to planning and developing a module, each intern was required to gain approval from PTEI for his/her module. This approval could be acquired at a pitch meeting. The intern reported specific details including relevant background information, the objectives and goals of the activity, the experimental procedure, and the anticipated budget. After each module proposal, the members of PTEI discussed the pros and cons of the activity, suggested changes and adaptations to the design, and either approved or denied the project.

The design proposed to PTEI at the pitch meeting for the Daphnia Magna module reported three main objectives. The first was to observe the heartbeat and calculate the heart rate of a Daphnia Magna, second was to observe the effects of the various drugs on heart rate, and third was to compare and discuss class results. The goal specified was to compare the effects of different drugs on heart rate using Daphnia Magna as a model. Daphnia Magna, which are small water crustaceans, were selected as the model because of their size, 3mm-5mm, and semi-transparent nature [3]. These characteristics made the specimens ideal models to observe their beating hearts under a microscope. The procedure was also detailed in the presentation to PTEI and overall estimated cost was $260.64. The module was awarded approval and further planning commenced.

After gaining approval for the proposed modules, it was essential to begin preparing the summer camp supplies. This included ordering and organizing materials required for each activity, as well as devoting time to cell culturing and plating for several of the modules involving stem cells and yeast. To maintain thorough bookkeeping and a high sense of order in the stockroom, it was crucial to create a detailed list of inventory for all of the obtained supplies.

Due to the fundamental necessity to practice in order to improve skill, the final step of preparation was a mock camp. The mock camp was a training exercise utilized to increase familiarity and proficiency with experiments, increase comfort level, and decrease errors during the actual camp. The mock camp occurred in the week prior to the actual summer camp.

Following the mock camp, the PTEI summer camps were held in Pittsburgh, Pennsylvania for two weeks and in Greensboro, North Carolina for one week. Upon arrival, attendees were organized into groups of three to four campers. Each group was designated as a tissue engineering company with a unique name and logo to be created by the students. Every tissue engineering company was assigned an undergraduate intern who interacted closely with the group and functioned as the CEO. The interns assisted the students in their assigned company by guiding them through the experiments and serving as a mentor. Throughout the course of the week,
the companies competed against one another to earn money by excelling in the numerous modules.

In the module, “Monitoring Daphnia Magna Heart Rate,” each student was provided a Daphnia Magna specimen for observation. They first determined the resting heart rate of the specimen by placing the specimen on a concavity slide and viewing the beating heart with a microscope. Students recorded the number of beats that occurred in 15 seconds and multiplied the result by four to determine heart rate in units of beats per minute. Next, the student treated the specimen with 100 microliters of caffeine, aspirin, adrenaline, or ethanol by pipetting the solution onto the concavity slide. They then recalculated heart rate and determined percent change.

Overall, the success of the camp was measured by pre- and post- test analysis. The pre-test occurred prior to the start of activities and the post-test occurred at the week’s end. The results were provided to Dr. Kalyani Raghavan, who analyzed the tests and returned a report to PTEI. The results only reflected the 44 students who attended the camp in Pittsburgh, as the results from the Greensboro camp were not provided.

RESULTS

Each module in the summer camp generated noteworthy results. In the case of the Daphnia Magna module, students observed trends of increased heart rate in specimens treated with caffeine and adrenaline, decreased heart rate in specimens treated with ethanol, and little to no change in specimens treated with aspirin. Through this activity, students became more familiar with Daphnia Magna anatomy, the proper techniques for using a microscope, and the concept of heart rate. However, the success of the camp was measured on a larger scale, considering the modules as a whole entity instead of isolated successes or failures. To analyze the success of the camp, it is necessary to consider the pre-and post-test results.

Regarding the pre-test, the average score achieved by middle school students was a 53 percent, which increased to a 71 percent on the post-test. Figure 1 exhibits the students’ pre- and post- test achievements on a per question basis. It was notable that every student showed an increase in score with the exception of one student who scored the same on both tests. The high school students also demonstrated success, with an average pre-test score of 27% and an average post-test score of 59%. The per question results for high school students are displayed in Figure 2.

![Figure 1: The results of the students’ pre- and post-tests illustrating what percentage of students correctly answered each question. These results showed an increase in ability to answer in all but two questions and an 18 percent increase in the overall score.](image1)

![Figure 2: The results of the high school students’ pre- and post-tests illustrating what percentage of students correctly answered each question. These results noted a consistent increase in ability to answer all questions at the end of the week and an increase of 32 percent in the overall score.](image2)

DISCUSSION

Due to the results of the pre- and post-test analysis, it was determined that the success criteria were achieved. Students exhibited a large increase in overall ability to answer questions related to tissue engineering and bioengineering, showing that the students had increased their knowledge throughout the week. Students also reported that the camp increased their interest in science, causing them to consider pursuing science in their academic futures.

CONCLUSION

The lack of STEM curriculum in classrooms today has become a clear cause for concern in the United States. With less focus on STEM in schools, students have fewer opportunities to explore advanced topics. The Pittsburgh Tissue Engineering Initiative summer camp allows students to learn about tissue engineering in a manner that successfully increases knowledge of tissue engineering and explores students’ interests in science.

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REFERENCES

