A SIMPLE, NO-COST, CONVERSION OF A DESCRIPTIVE LAB EXERCISE TO ONE THAT PROMOTES CRITICAL THINKING AND HONORS-PROGRAM PARTICIPATION

William P. Rivers, SUNY Canton, Canton, NY

ABSTRACT

Our undergraduate microbiology course has historically served 2-year nursing students and 2-year veterinary technology students. The laboratory exercises for this course have largely been descriptive rather than experimental. In an effort to increase the critical thinking skills of our students and to better serve the growing number of 4-year nursing and 4-year veterinary students, I have developed a simple methodology for changing a lab designed to merely sample microbes in the environment to one that answers two, basic clinical questions: How long does a sterile field stay sterile?, and Which method of hand cleaning (hand washing or alcohol-based hand sanitizer) is most effective? One hundred students were randomly assigned to one of three treatment groups for each experiment. For experiment one, students exposed sterile nutrient agar plates to the air for 1, 15, or 30 minutes. For experiment two, students placed their index, middle, and ring fingers onto the surface of a sterile nutrient agar plate either after washing their hands with soap and water, using an alcohol-based hand sanitizer, or doing nothing. Plates were incubated at room temperature for one week and then the number of colonies on each plate was counted and treatment comparisons were made and discussed. These two experiments are designed to facilitate critical thinking and allow students opportunity to relate these lab exercises to practical clinical issues. This shift toward more experimental laboratory exercises also provided opportunities for more advanced students to develop research posters which they presented at our college's nascent honors program symposium.

INTRODUCTION

In recent decades many educators have recognized the importance of inquiry-based labs that increase student's ability to think critically (Hoefnagels and Walvoord, 2005; Laine and Heath, 2000). The process of converting labs from descriptive to more experimental, however, can be labor intensive and/or expensive. Due to budget and time constraints, it is not feasible for us to increase the per student cost of each laboratory or have students conduct individual research projects. The introductory microbiology course at SUNY Canton is required by our associate degree programs in nursing and veterinary technology. It enrolls around 100 undergraduate students per semester and is divided into 2 lecture sections and 5 laboratories. The goal of this project was to begin to improve the laboratory portion of this course by making lab exercises more experimental rather than descriptive. This project was also motivated by a desire for students to better understand the relevance of microbiology to their future professions and to have an opportunity to practice critical thinking skills when presented with questions of clinical significance.

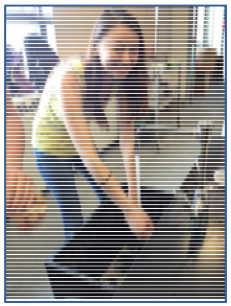

Figure 1.Washing hands with soap.

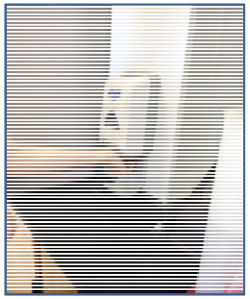

Figure 2.Using Purell hand-sanitizer.

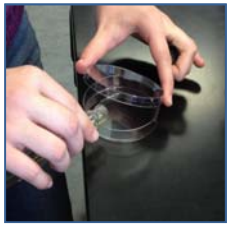

Figure 3. Pouring an agar plate.

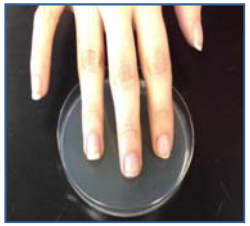

Figure 4. Exposing agar plate to fingers

METHODS and RESULTS

A descriptive lab exercise that involved environmental sampling of microorganisms was chosen for modification. The original lab required students to pour four nutrient agar plates per pair of students and sample four environmental surfaces or air of their choosing. Suggestions for plate treatments included exposing agar plates to air for 15 minutes, fingers, desktops, swabs from teeth, cell phones, door knobs, and toilet seats. To convert this lab exercise into one that was experimental I identified two independent variables that could be easily controlled that have clinical significance:

Independent Variables = Air exposure time (1, 15, or 30 minutes), and hand cleaning technique (soap and water, Purell, or nothing). Dependent Variable = Number of microbial colonies present on culture plate after one week

At the beginning of the revised version of this lab, students were instructed to either clean their hands using soap and water (figure 1), or Purell hand sanitizer (figure 2), or do nothing. After pouring two nutrient agar plates each (figure 3), students were instructed to open one of the plates to the air for either 1, 15, or 30 minutes, and with the other plate place their index, middle, and ring finger onto the surface of the agar (figure 4). After one week of incubating at room temperature all colony forming units (c.f.u.) were counted (figures 5 and 6) and the results were discussed.

Control (nothing) Soap and Water Purell

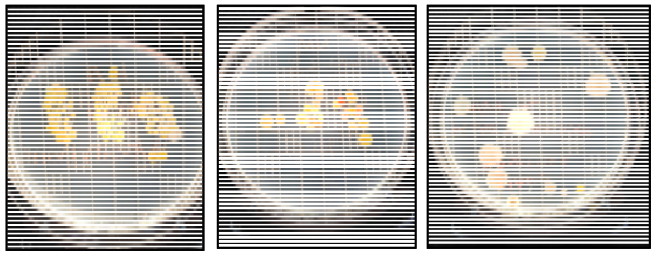

Figure 5. Examples of plate cultures from hand-washing experiment.

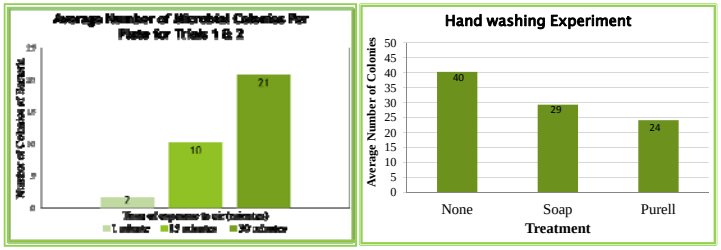

Figure 6. Student-generated bar graphs showing the average number of CFU's for each treatment.

RESULTS continued

- A class-wide data set was compiled for each of these experiments and presented to the class during lecture for analysis and discussion.
- In groups of four, students were asked to come up with 2 hypotheses to explain the results from each experiment and 2 ways to modify the experiments to improve them.
- Students were then asked to discuss the clinical implications of the results for each experiment.
- Two students used each of the compiled data sets to develop poster presentations at a new campus-wide honors symposium (figures 7 and 8).
- No-increase in per student laboratory materials costs was incurred.

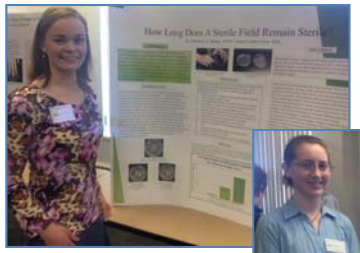

Figure 7. Microbiology student and honors-symposium participant, Rebecca Burns.

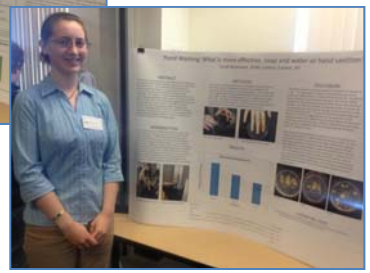

Figure 8. Microbiology student and honors-symposium participant, Sarah Newtown.

DISCUSSION

During the discussion of the results of the sterile field experiment, students expressed amazement at how quickly and consistently an exposed sterile field becomes contaminated. All but one plate was contaminated after 60 seconds. Questions such as "Where are all these microbes coming from?" and "How could someone ever prevent contamination?" were commonly asked. This lead to a discussion of the normal human microbiome and the importance of personal protective equipment and positive pressure rooms with HEPA air filtration in any situation that requires sterility.

During the discussion of the results of the hand-washing experiment, students generated hypotheses to explain the observed differences between the treatments. They identified sources of variation such as prior individual hand-washing behavior, and air-flow patterns in the laboratory. They also were shocked to learn that neither washing with soap and water nor Purell hand sanitizer removed ALL of the microbes. This led them to the realization that only a barrier, such as sterile gloves could prevent contamination of a sterile field.

Finally, in addition to the improved class discussion, the two more advance students in the class that presented posters at the newly created campus-wide honors symposium were challenged in three key ways. 1) It required them to conduct a literature search to find out what similar experiments had been conducted. 2) It had them formally write up the methods, results, and discussion of the experiment in a formal report, and finally, 3) it gave them an opportunity to present their posters in a public venue.

FUTURE DEVELOPMENT PLANS

This exploration of how I can easily improve the quality of the microbiology laboratory exercises with no increase in per student costs and minimal increase in time has me thinking about additional improvements I could make to this and other lab exercises. These include:

- Enforce a more stringent hand-washing technique to help reduce variation
- Add a no-exposure control to test for sterile pour-plate technique
- Introduce the use of basic descriptive statistics and tests such as the student's t-test
- Include before-and-after tests of different hand cleaning treatments
- Have students submit a summary paragraph of the clinical significance of the results of these two experiments
- Others ideas?

LITERATURE CITED

Hoefnagels, M. and M. E. Walvoord. 2005. Conversion immersion: working together to create investigative labs. In *Tested studies for laboratory teaching*, vol. 26 (M.A. O'Donnell, Editor). Proceedings of the 26th Workshop/Conference of the Association for Biology Laboratory Education (ABLE), June 2004.

Laine, P. S. and L. J. Heath. 2000. Introducing inquiry. Pages 417-423, *in* Tested studies for laboratory teaching, Volume 22 (S. J. Karcher, Editor). Proceedings of the 22nd Workshop/Conference of the Association for Biology Laboratory Education (ABLE), 489 pages.