The Goggle Lab: Using Impairment Goggles to Teach Science Competencies

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ABSTRACT

In its 2011 report Vision and Change in Undergraduate Biology Education, the American Association for the Advancement of Science emphasized the use of core concepts and competencies from multiple disciplines rather than focusing on rote memorization. After the publication of this document, many individuals, departments, and institutions started using course-based undergraduate research experiences (CUREs) as one way to transition to the inclusion of core competencies. Well-executed CUREs focus students’ learning of science practices around a project that relates to a real problem the students are helping solve. However, while CUREs are effective and can be fun for both students and instructors, not every instructor or institution has the time or the funding to engage students in a formal CURE project. This means finding alternative ways to incorporate teaching core competencies and science practices. We created the Goggle Lab to use impairment goggles, which simulate the effects of alcohol and other substances, in a general biology laboratory setting to teach core competencies and science practices, while injecting a dose of fun and integrating social issues. Students utilized the impairment goggles to design experiments, analyze data, practice basic statistics, and communicate scientific findings in a variety of formats.

Keywords: science practices; nature of science; impairment goggles.

Introduction

Understanding basic science practices is essential for biology students and promotes scientifically “informed citizens” in nonmajors biology courses. The American Association for the Advancement of Science (AAAS, 2011) has emphasized the importance of focusing on core competencies: applying the process of science; utilization of qualitative reasoning modeling and simulation; highlighting the interdisciplinary nature of science and collaboration with other disciplines; and understanding the relationship between science and society. To address this charge, many institutions have pivoted from weekly, self-contained labs to course-based undergraduate research experiences (CUREs). However, these intensive experiences pose budget and time issues according to faculty (Shortlidge et al., 2016). Additionally, intensive lab-based courses, while pedagogically sound, may require a high cognitive load of students (Schmidt-McCormack et al., 2017) and instructors leading to frustration and lack of student buy-in. Therefore, less intensive alternatives that (1) provide students with an engaging laboratory activity (2) that is scalable and budget-sensitive while still (3) meeting core competencies may be a more attractive option. This lab offers a budget-sensitive solution; many labs have flat or increasing cost per student each year, whereas this lab has a reduced cost per student each year because the goggles – while a significant up-front cost – are non-consumable.

Active learning encompasses a number of different teaching methodologies; the core tenet of active-learning activities is that students must be the driving factor in solving a problem (Graham et al., 2013). Active-learning labs that are engaging and incorporate timely, real-world issues can improve student understanding of science content and practices while increasing science literacy and the incorporation of science into students’ daily lives (National Research Council, 1996, p. 22). One way to engage students in labs and promote this change in thinking is to make the lab an experience that has real-world implications. When learning science practices like experimental design, students may be asked to solve a problem that is too simple to be a real-world problem (Why does temperature increase reaction rate?), too complex for them to solve (Effects of acidic and basic environments on enzyme active site reactivity), or not applicable to their interests (not everyone is excited about yeast inflating a balloon). If done properly, active-learning activities can help students apply big-picture ideas in real-world applications (Srinath, 2014). This can increase student learning, academic performance, social belonging, and confidence in academic abilities (Ballen et al., 2017). However, if you can create a lab experience that is not only hands-on, but interesting and applicable to current life issues (e.g., why impaired driving is dangerous), you can teach science practices and help students use the information learned to make life choices, all while having fun and laughing in the lab.

We elicited laughter in the lab while teaching science practices (e.g., experimental design, data analysis, and science writing) through utilization of impairment goggles. These devices are...
frequently used in police-community or D.A.R.E. type programs to teach people about the dangers of operating vehicles under the influence of alcohol, drugs, or sleep deprivation. Many high school and college students are inundated with programming about the dangers of impaired driving while buzzed, drunk, under the influence of THC-containing products, or sleep deprived – all factors that may affect their ability to drive. Additionally, the laws governing such behavior are changing rapidly. As a result, many students have questions about the true dangers of these activities, potentially asking questions like “How bad could it really be?”

○ Course Context

Students inherently want explanations for why they are told to do or not to do things. We developed the Goggle Lab to help them answer these questions by utilizing impairment goggles. Teaching the scientific method and experimental design can be a tedious process for instructors as well as students. However, this lab provides students with a chance to actively engage with the experimental process in a semi-structured environment. Unlike overly helpful labs that ask students to provide “known answers,” the open-ended nature of this lab allows students to participate in more realistic experiences. As students progress through the scientific method, they start by proposing hypotheses with a real-world application, analyze data, and practice reporting data in multiple formats.

The pilot course was General Biology Lab 1 (Bio 1). A course for biology majors, Bio 1 focuses on teaching students science practices, from experimental design to dissemination. Over the course of the semester, students design and carry out three major experiments that cover multiple weeks (enzyme efficacy), and four traditional lab exercises (e.g., osmosis, microscopes). Students enrolled in this course are typically dance, education, or engineering majors. After piloting the lab in Bio 1, we implemented it in a nonmajors Human Biology Lab (Human Bio). Human Bio focuses on teaching students some science practices and takes a systems approach to teaching fundamental anatomy and physiology. Students enrolled in this course are typically dance, education, or pre-physics therapy majors. Therefore, we have tested the current lab with both nonmajor and major STEM students.

○ Details of Lesson & Exercise

Learning Objectives

After completing this lab, students will be able to complete four learning objectives: (1) Describe experimental design; (2) Explain the importance of using statistics in data analysis; (3) Interpret data; and (4) Paraphrase and cite literature (Table 1).

Pre-lab Preparation

Instructors should collect goggles and items needed for the experiment prior to the course. Our current lab utilizes four types of inebriation goggles: BAC 0.04–0.06, BAC 0.06–0.08, THC, and Sleep Deprivation. It is not necessary to utilize four different sets of goggles, or to utilize these specific ones; however, we recommend combinations that test different factors and model real-world problems. For the experimental activities, collect items for at least two activities that focus on different aspects of impairment. To test balance, instructors can have students perform a drunk walk along a tape line on the floor. To test depth perception, instructors can utilize paper cups with a set number of coins. Finally, to test hand-eye coordination, stress balls and an empty bucket or box can be utilized.

Again, these exact experiments are not necessary – utilize what you have and what will work best for your students. When choosing experiments, you should also be mindful of your students’ physical limitations and any accommodations that may need to occur. In some cases, you may need to accommodate different learning abilities in class. Students do not necessarily need to complete every activity themselves. Students with physical limitations might take on the role of the experimenter and track the data while other lab partners perform the experiments. In the end, the objective of the lab will be achieved as long as everyone has access to course data for analysis and completing the writing assignments (if you choose to use that portion of the lab).

Lab Introduction

The Goggle Lab begins with a brief background on experimental design, the use of statistics in science, and the general activities for the day (see the Supplemental Material available with the online version of this article). In the lab handout, the impairment goggles are described as THC, Drowsy, BAC 0.04–0.06 (“buzzed”), and BAC 0.06–0.08 (“drunk”) impairment goggles. Additionally, students are told the class will perform a set of activities (walking along a line, picking up coins, and/or a ball toss) to determine the impact the impairment goggles have on students’ abilities to complete the activities. Students are then asked to work either in groups or as a class (depending on instructor preference) to create a hypothesis about the outcomes of each activity based on the type of impairment goggles in use.

An important aspect of experimental design is teaching students how to develop appropriate hypotheses and predictions, as well as the difference between the two. Hypothesis development is a hard concept to teach and for students to understand (Strode, 2015). At the basic level, a hypothesis is a statement that is both testable and falsifiable. For instance, a hypothesis may be that “there is a difference in coin pickup speed between people wearing THC and Drowsy goggles.” At this point, instructors discuss the differences in the null and alternative hypothesis testing. Students work together to create a prediction for each activity and design the parameters of the experiment, identifying controls (i.e., how to walk heel to toe,
in which order they have to pick up the coins) as well as dependent and independent variables. With each experiment, instructors should also stress laboratory safety. For instance, we recommend using “spotters” for balance tests and having students in a seated position for other experiments.

Next, students write up the methodology determined by the class for each activity and create a data table to record their results. This lab stresses the importance of experimental and control groups. While most students have no problem walking the line or picking up coins without any goggles, there is some variance among individuals, which ultimately can impact the data. Taking time to stop and talk about this variance will help students recognize that things as simple as the choice of footwear or the length of fingernails can impact subject performance and thus the data. The instructor provides the basic outline; however, students are responsible for experimental parameters such as the position of their test subject’s arms when walking the line, placement of the cup and coins, and what counts as a “missed” step. When students actively participate in the design process rather than following an instructor’s set of rules, they are asked to visualize the experiment and think critically about small variables that might confound their data. Additionally, the importance of good experimental design and data collection practices are emphasized since individual groups will be performing the experiment, but the data will be pooled.

**Lab Investigation**

Students work in groups (about four to a group) to complete the activities with each set of goggles (the time required depends on how many goggles are used in each lab). The activities are not completed in sequence, but rather in order of material availability. Students then record the data in their handouts and transfer the data to a class datasheet managed by the instructor. After the data have been collected, the instructor talks through how to conduct a t-test or ANOVA (depending on how many/which types of goggles were used) and demonstrates how to complete the tests in Excel. After the results are posted, students transfer them to the appropriate boxes in the lab handout and determine if there were or were not significant differences between the goggles types used. This lab serves as a primer to introduce students to this process for future labs in the course.

Running and interpreting statistical tests can seem like an insurmountable hurdle. Instructors may be unfamiliar or uncomfortable with walking students through the process, and negative student attitudes toward math can also complicate the issue. Using the Goggle Lab, we have focused students on the interpretation and meaning of the statistics rather than the process of performing the tests themselves. Using Excel, students follow along with the instructor as means and standard deviations are calculated. Instead of worrying about the formula, students are engaged in thinking about what an average or a standard deviation is really communicating. Students then perform t-tests and apply them to their hypothesis. While students need to understand significant versus not significant, it is more important to identify what that means in the context of the data. Instead of saying “there was a significant difference between Sleep Deprivation and THC in the walk the line experiment,” students are encouraged to move to a deeper level of understanding, such as “THC goggles have a greater effect on balance than sleep deprivation goggles based on the walk-the-line test.” Or in the instance of the coin pickup test, students explore how each impairment type affects depth perception and the impact that could pose to driving.

**Post-lab: Science Communication**

There are a variety of options for having students communicate their laboratory findings, which can be adapted based on course objectives and/or time availability. The essence of any of these assignments includes conversations about how to interpret data (what do those numbers mean anyway?) and how to share those interpretations with a specific audience. Here are some ideas for science communication activities:

**Answering Questions in a Lab Handout**

- **Rationale:** This provides a way for students to practice compiling, organizing, and analyzing class data in a way that is also quick for instructors to review/grade.
- **Examples:** Comparing t-test vs. ANOVA tables, interpreting results (Supplemental Material: Appendices S1 and S2)

**Completing a Formal Written Report**

- **Rationale:** A lab write-up gives students practice in writing methods and results, drawing conclusions from data, finding scientifically relevant sources and incorporating them into writing, and following formatting instructions. You can emphasize that formal writing can be concise as well as informative. Students can work in groups to find appropriate and relevant scholarly sources, as well as practice paraphrasing information, writing explicit methodologies and results in paragraph form, and using graphing software.
- **Examples:**
  - Mini Manuscripts that focus student writing on specific portions of a scientific paper (low-stakes) to practice specific areas of formal manuscripts before writing formal lab reports (Supplemental Material: Appendix S3)
  - Formal Lab Reports in which students work on synthesizing information from multiple places (i.e., scholarly literature and collected data) to write meaningful conclusions, and learn how to use word processing software to format documents (all of these skills can then be referenced and built upon in later course assignments)

**Completing an Informal Writing Assignment**

- **Rationale:** Teaching others helps you learn. Scientific literacy is about being able to review/synthesize information presented for accuracy, but also to share technical information with a broader audience. Practicing informal writing as compared to formal lab reports (below) provides students an opportunity to synthesize information in a different way, showing their understanding of the topic.
- **Examples:**
  - Composing sharable content via a mock news article (or one for their school newspaper), a Twitter thread, or Facebook story (Supplemental Material: Appendix S4)
  - Constructing a visualization story via infographic, comic strips, Instagram posts with appropriate hashtags
  - Creating a video story via short videos (less than two minutes), Snaps, Vines, or stop-motion animations
  - Any other visual not used in formal science presentations to present their findings
Having a variety of informal and formal assignment options gives students the chance to choose something they like, which may increase buy-in to complete the assignment. They also provide insight into how students think about information. These insights can be used to shape how you discuss science practices in the future.

Alignment

This lesson meets multiple Next Generation Science Standards (NSTA, 2013) Science and Engineering Practices and AP Biology Science Practices (College Board, 2019) (Table 2).

Conclusion

The Goggle Lab detailed here offers a less intensive alternative to CUREs that achieves many of the same core learning outcomes while being more scalable and flexible than semester-long research projects. This lab offers a way to introduce key concepts of experiment design, data collection and analysis, laboratory safety, and scientific writing that ultimately contribute to foundational scientific literacy in students. Furthermore, this lab can be adapted to place further emphasis on a range of different scientific skills, such as statistical analysis, engagement with scientific literature, and interpretation of laboratory data/results.

For students, this lab offers a challenging, active learning experience that builds foundational scientific literacy while also being fun and engaging. After they participate in the Goggle Lab, we have noticed students asking more complex questions about things like experiment design rather than superficial questions that can be answered by a simple internet search. The topics covered in the Goggle Lab (i.e., influence of alcohol and drugs), allow students to see how science plays a role in their life. For faculty, this lab offers an adaptable, budget-sensitive way to achieve the benefits of larger research projects with a fraction of the time and resources such projects require. Anecdotally, instructors who implement this lab have found less student confusion and a better understanding of experimental design in subsequent labs. Additionally, more instructors at both our institution and an area high school are adopting the Goggle Lab, suggesting wider viability beyond this initial pilot.

Acknowledgments

Thank you to Ryan Barney, Karl Jarvis, and Samuel Wells for sharing course materials and ideas with us, and implementing this project in your classes. We would also like to acknowledge the number of iterations that this project went through to get to the stage it is at now and thank our students for working with us while developing this lab.

Table 2. Alignment of the Goggle Lab with Next Generation Science Standards and AP Biology Science Practices.

<table>
<thead>
<tr>
<th>Practice</th>
<th>Goggle Lab</th>
<th>Goggle Lab with Writing Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>NGSS</td>
<td></td>
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<tr>
<td>Asking Questions                                                          X</td>
<td>X</td>
<td></td>
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<tr>
<td>Developing and Using Models</td>
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<td>Planning and Carrying Out Investigations</td>
<td>X</td>
<td>X</td>
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<td>Analyzing and Interpreting Data</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Using Mathematics and Computational Thinking</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Constructing Explanations and Designing Solutions</td>
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<td>X</td>
</tr>
<tr>
<td>Engaging in Argument from Evidence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obtaining, Evaluating, and Communicating Information</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>AP Biology</td>
<td></td>
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<tr>
<td>SP1 – Explain biological concepts, processes, and model presented in written format.</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>SP2 – Analyze visual representations of biological concepts and processes.</td>
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<tr>
<td>SP3 – Determine scientific questions and methods.</td>
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<td>X</td>
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<tr>
<td>SP4 – Represent and describe data.</td>
<td>X</td>
<td>X</td>
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<tr>
<td>SP5 – Perform statistical tests and mathematical calculations to analyze and interpret data.</td>
<td>X</td>
<td>X</td>
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<tr>
<td>SP6 – Develop and justify scientific arguments using evidence.</td>
<td></td>
<td>X</td>
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References


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