# Introductory Biology Lab - An Active Learning, Group-based Lab Course, Using a Team-Taught Modular Approach

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Summary and Goal of the project:

Biology 112 is a newly-designed, team-taught modular course based on the discovery method and rooted in the belief of the essentiality of introducing a large (150+ students), multidisciplinary freshmen class to the practice and process of science. Our approach is designed to maintain and enhance student interest in the sciences while providing them with a progressively sophisticated experience with the process of science. Faculty would develop modular content based on desired student outcomes with appropriate assessment tools within the framework of that module.

The assessment within and between modules is what we would like to continue to explore and develop. The project questions include: 1) How do we improve assessment of student skill mastery within a module? Can we create a common framework regardless of content? 2) How do we assess progressive improvements in student ability to do science across the different modules?

Background:

There are many assessment tools that are available for biology courses. Our literature review focuses on those studies which include team-taught modular design in a large class setting. In modular design (*Gaffney, et. al., 1995),* students receive several limited lab exercises with an immediate, targeted feedback for students in each module. A positive aspect of this study and others (*Oh, et. al., 2005*) is the concept of inter-evaluator reliability, where there are multiple evaluators provide legitimacy for consistent and valid grading rubrics. We hope to formalize this approach to give students more feedback for improvement throughout the course.

There are many valuable sources for assessment, but we have adopted the backwards design paradigm (*Wiggins and McTighe, 1998*). This is considered to be a model system for evaluation in education. In this model, educators set goals tied to measurable student outcomes. Over-arching standards for assessment can then be used to develop specific assessment tools which can measure student success at achieving those outcomes.

## Approach:

Having designed the course to meet learning objectives, we used assessment tools to try to determine if our objectives were met. Most of these were evaluative, though more formative tools are in place and need to be analyzed in the future. We conducted pre-, and post- test analysis of student's understanding of the content and process of science for the course and each module. We gave pre- and post-course attitudinal surveys and a post-module attitudinal assessment. In addition we plan to do post-course follow-up data collection in the following years to determine whether students are more likely to participate in undergraduate research and whether students do better in their course/lab work.

## Results:

Since the goal of the project was to prepare students to understand, appreciate and utilize the scientific method, many of our pre- and post survey questions were designed to assess both subjectively and objectively whether students showed marked improvement. The most significant results are depicted in the figures below.

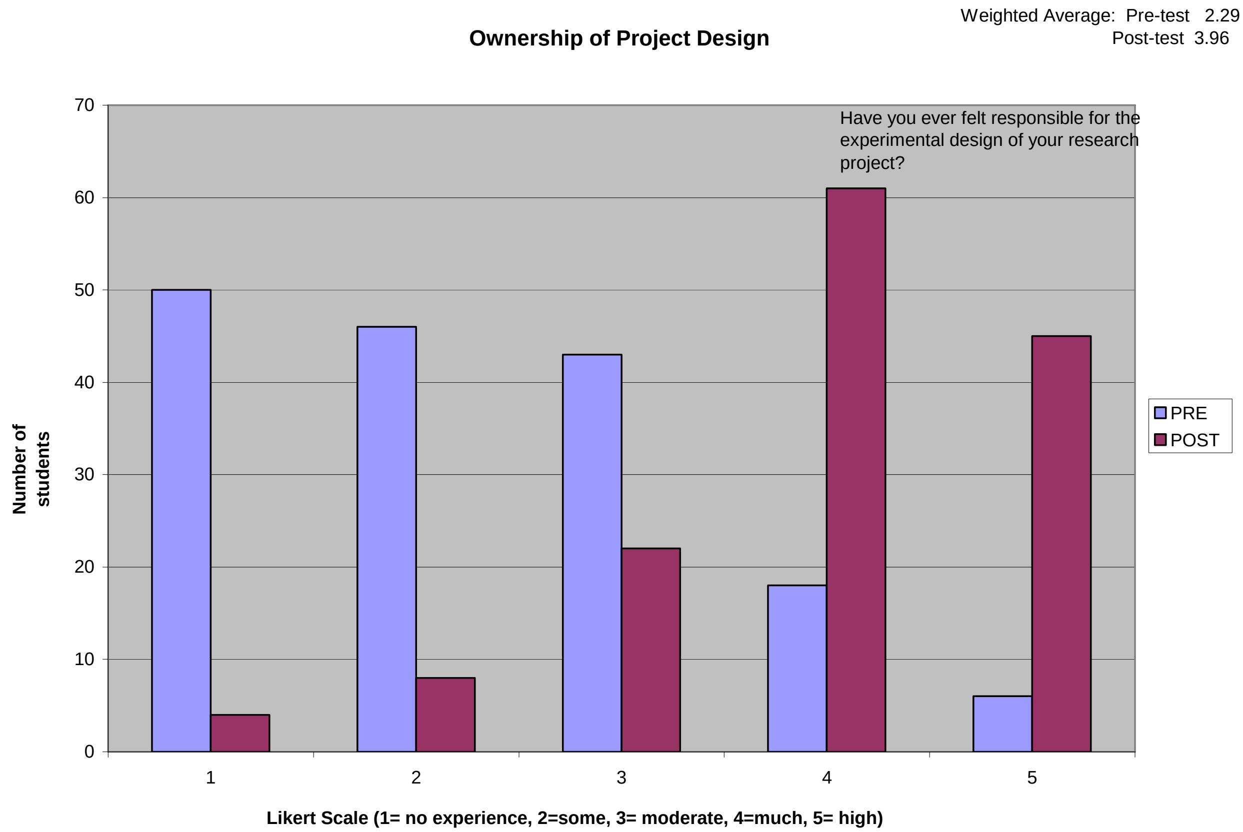


**Figure 1. Ownership of Project Design:** *"Have you ever felt responsible for the experimental design of your research project?"*

Most of our student's previous experience in a laboratory setting was with experimentation where an outcome was known, or they had no role in designing (and therefore understanding) the experiments and the underlying hypothesis testing. Because this course was designed to progressively expose students to scientific method, we wished to determine whether students perceived or recognized that they achieved some measure of experience and ownership in experimental design by the end of the course. There was a significant shift in student's perception, pre- and post-, of their experience level in experimental design. This is a very important metacognitive element in utilizing the process of science in the laboratory.

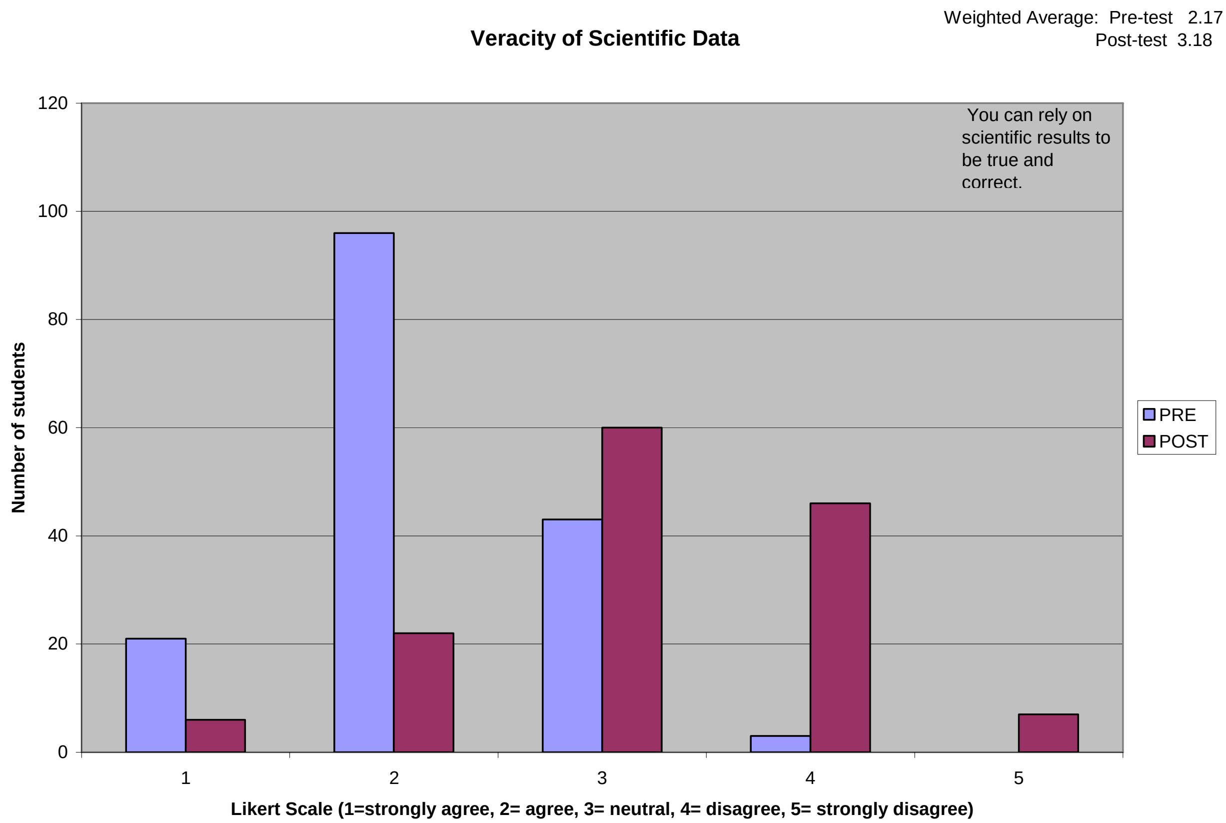


**Figure 2. Veracity of Scientific Data and Interpretation:** *"You can rely on scientific results to be true and correct."*

This question, while seemingly simplistic, is designed to explore how students perceive scientific results. Most of them have been drilled that science consists of facts, and not as a way of gaining knowledge and understanding. Without understanding the principle of falsifiability and the continuous evolution of scientific interpretation, they (as does the general public) assume that all scientific results are equally meaningful. One of our goals was to remove the veneer of science as fact, and open their eyes to the realization that valid scientific hypotheses must always be held up to new scrutiny and re-examination by new experimentation. There is a dramatic shift in this category where students move from general agreement with this statement to one of greater doubt, a sign of growth in their development as scientists.

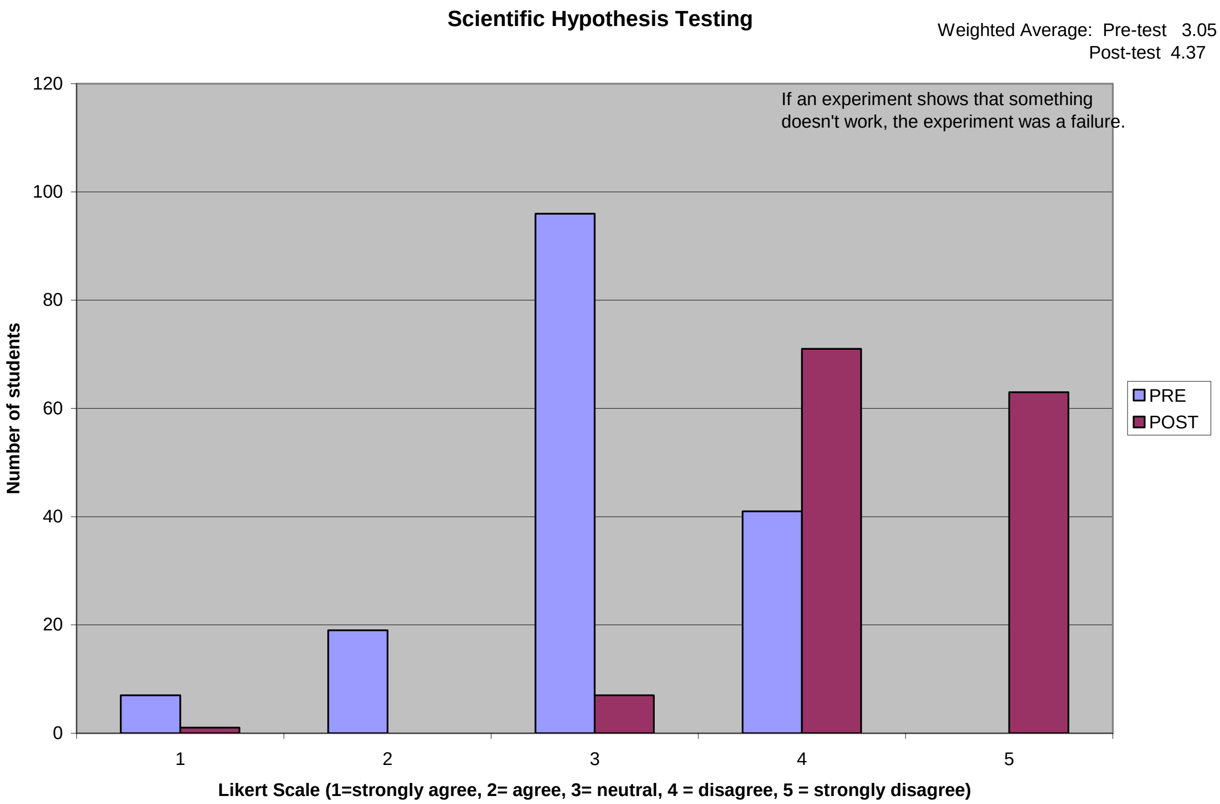


**Figure 3. Scientific Hypothesis Testing:** *"If an experiment shows that something doesn't work, the experiment was a failure. "*

If most of the students have only been exposed to 'canned' laboratories where the results are known and they are merely following 'cookbook' exercises, then have had little exposure to real scientific experimentation and hypothesis testing. It is to be expected that they would view a negative outcome as a failure. However, the essence of experimentation is that hypotheses are falsifiable; the failure of a properly designed and executed experiment may merely mean that the hypothesis is wrong, and that this is as valid an outcome as one that supports the hypothesis. One goal in the course is get students to recognize valid science will yield hypotheses where experiments don't work upon testing and the hypothesis needs to be reconsidered. There is a dramatic shift in the student's recognition that this statement about the value of an experiment with negative data; a majority disagree with this statement in the post-test.

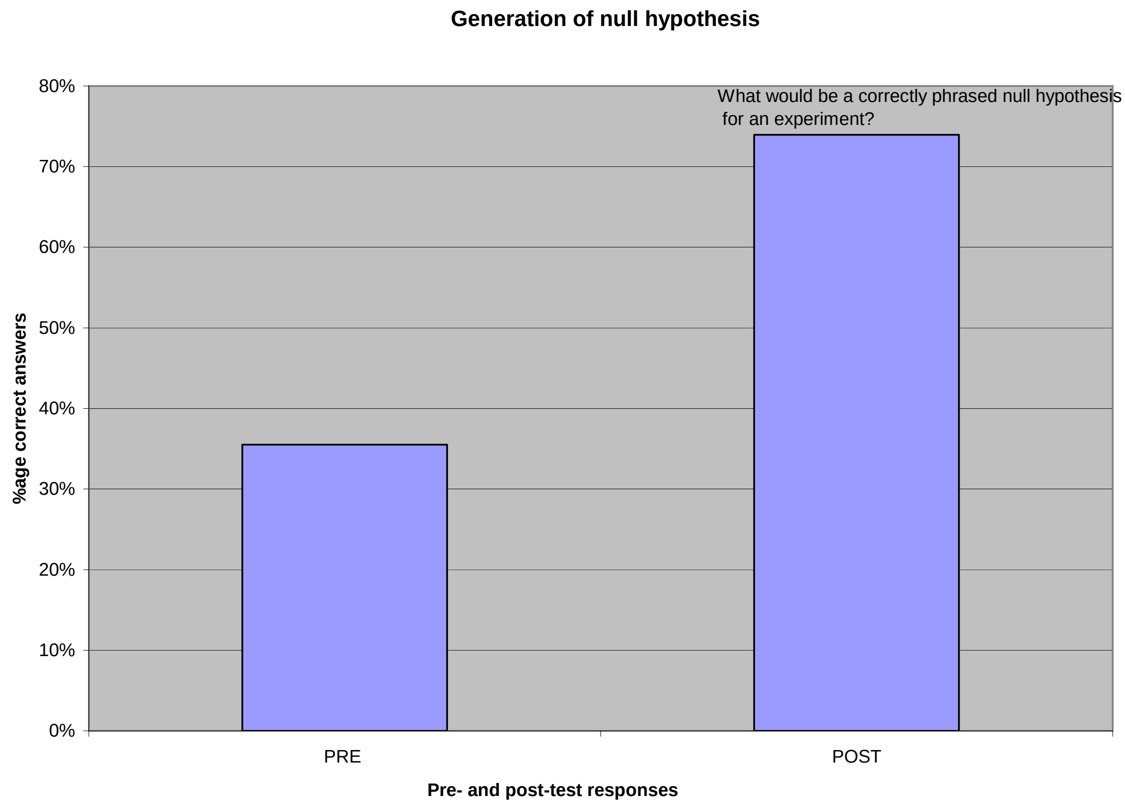


**Figure 4. Null hypothesis generation:** *"What would be a correctly phrased null hypothesis for an experiment?"*

We continue to seek objective measurements of progress in the student's understanding and use of the process of science. One such assessment tool is the administration of a battery of questions, pre- and post- test using multiple-choice questions, to measure any increase (or decrease). Along with a general set provided at the beginning and end of the course, we also administer a set of pre- and post-tests specific to each module. It has been a challenge to select appropriate questions which measure any change. One very clear, and promising, change is depicted in this figure. The null hypothesis is essential to understanding the hypothetico-deductive method and allows for a number of statistical methods used to analyze data. The number of students responding correctly to this question posed at the beginning and end of the course doubled indicating their understanding of this very important concept in utilizing the process of science has increased dramatically. We continue to develop questions which will reveal objective progress in student's grasp of the scientific method.

## Conclusions:

We have demonstrated some preliminary evidence that some of our learning objectives have been met. The assessment data is promising in some of the areas outlined above, and demonstrates that backwards design of a course can be particularly effective in reaching learning goals and achieving specific pedagogical outcomes. Clearly there is more work to be done, both in refining some of our assessment tools, and in collecting more data, both of which are being worked on. We think this is an exciting beginning of a very different, and effective new course, which will hopefully be a template for more courses in our Department and even modeled by other colleges.

## Dissemination:

The design and assessment of this course was presented in a poster at the Lilly West conference (March 2007, Cal Poly Pomona), and will be presented at the Scholarship of Teaching and Learning Showcase (September 2007). In addition, we gave an oral presentation at the Center for Teaching Excellence (LMU) in April 2007. We plan to continue and improve assessment and we hope to publish a paper about the course within the next year.

## References:

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