An Experience With Astronomy Lab Development And Improving Laboratory Pedagogy

By: Mariah N. Birchard and David J. Sitar

Abstract

Optics can be a challenging subject for students that are not pursuing a science major. A well-organized lab exercise aids students in better understanding content and provides more opportunities to reaffirm the knowledge they obtained through lecture. To orchestrate a successful lab activity it is vital to account for the diversity of knowledge and experience; as such, extra measures have to be taken to ensure every student learns. Integrating this mindset, we created an “Optics and Telescope” lab activity that encompasses strengthening pedagogy. We felt that our previous “Optics and Telescope” activity was not meeting the needs of our students due to the equipment it used and the format of the activity itself. To determine whether our new lab exercise was successful, we created an experiment that tested the previous lab format versus our newly developed format.

An experience with astronomy lab development and improving laboratory pedagogy

Mariah N. Birchard and David J. Sitar, Appalachian State University, Boone, NC 28608; sitardj@appstate.edu

Optics can be a challenging subject for students that are not pursuing a science major. A well-organized lab exercise aids students in better understanding content and provides more opportunities to reaffirm the knowledge they obtained through lecture. To orchestrate a successful lab activity it is vital to account for the diversity of knowledge and experience; as such, extra measures have to be taken to ensure every student learns. Integrating this mindset, we created an “Optics and Telescope” lab activity that encompasses strengthening pedagogy. We felt that our previous “Optics and Telescope” activity was not meeting the needs of our students due to the equipment it used and the format of the activity itself. To determine whether our new lab exercise was successful, we created an experiment that tested the previous lab format versus our newly developed format.

Method

The new lab activity was assembled by using PASCO optical benches and equipment (Model No. OS-8515C) along with the guidance from three of their lab write-ups. The experiment concentrated on retention, comprehension, and application. During the spring 2015 semester three astronomy lab nights (AST1001) were involved in the experiment: Monday, Tuesday, and Thursday. The labs consisted of two sections on each night, one early (8:00–9:50 p.m.) and one late (10:00–11:50 p.m.), with approximately 120 students participating. Monday’s early section participated in the new lab activity and the late section followed the old lab format, and on Tuesdays and Thursdays the early labs participated in the old activity and the late labs followed the new format. All student work was submitted anonymously.

Old lab activity

The old lab activity utilized outdated equipment, which has a problematic design that makes it difficult to position all lenses/objects along the same optical plane. This created issues while focusing an image, as demonstrated in Fig. 1. The old lab exercise was nine pages with 24 total questions contained in one section. There were nine math problems, one conceptual, and the remaining were data collection responses. The instructions were at the front of the lab activity, so students did not have direct access to the material; instead they had to flip from page to page to complete a procedure. In addition, the lab manual was not well organized or divided into sections, and the number and variety of questions was limited.

New lab activity

The new activity has new PASCO optical benches with easy to slide lenses and screens that are all aligned along the same optical plane, as seen in Fig. 2. The new lab consists of 12 pages divided into three different sections: Focal Length and Magnification of a Thin Lens, Focal Length and Magnification of a Concave Mirror, and Building Telescopes. There are a total of 56 questions, 25 of which are mathematical, nine conceptual, and the remaining are data collection responses. Repetition is utilized to reinforce the newly learned concepts. Instructions are located throughout the lab providing visual guidance to aid in self-sufficiency. The lab activity enhances and fortifies the following pedagogies: data-based learning, partner-based and collaborative learning, as well as developing more problem solving skills. Critical thinking and experimental learning are also present by adding additional conceptual and mathematical questions.

Assessment and results

Quantitative and qualitative analyses were used to determine which lab activity proved to be most successful. Scores for the old (in gray) versus the new (in gold) activity were recorded to see which was higher. As shown in Fig. 3, higher
20% higher than old scores and the difference between the two labs is very significant ($p = 0.002$), so it’s unlikely that the new lab got better scores purely by chance. Also, the new activity post-quiz grades were approximately 10% higher than the pre-quiz scores. Post-quizzes increased at a higher rate and the overall majority of students expressed in surveys that they enjoyed the new activity and would welcome the idea of implementing it into the manual. Even though the lab is very math intensive, some students shared that they appreciated the challenge. On the contrary, students that participated in the old lab activity expressed that they were confused and had a difficult time completing it.

**Conclusions**

New optical equipment improved usability and by strengthening language in the new lab manual, we helped students be more self-sufficient. The new lab activity proved to engage and enhance student’s knowledge, which allowed them to further explore optics. Therefore, due to strengthened pedagogy and the use of repetition, data indicates that the new activity was more successful. However, we would like to continue to evaluate this new activity due the study only involving small number statistics.

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**References**

2. ASU AST1001 lab manual (13-1 thru 13-10).

Looking back through TPT

Which articles from *The Physics Teacher* would you guess are the most popular? Here are a few of the manuscripts from *The Physics Teacher* that have been electronically downloaded most often in the past year, typically thousands of times already. Our congratulations go out to these authors, and our thanks also, for sharing their expertise and insights with us all!

- “Laser Soap Fountain” by Tyler Foley, Matthew Pegram, Zachary Jenkins, Brooke C. Hester, and Jennifer L. Burris in the January issue, *Phys. Teach.* 53, 10 (2015);
- “Negative Work Done by a Person” by Carl E. Mungan in the April issue, *Phys. Teach.* 53, 224 (2015);