



# 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.

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# An experience with astronomy lab development and improving laboratory pedagogy

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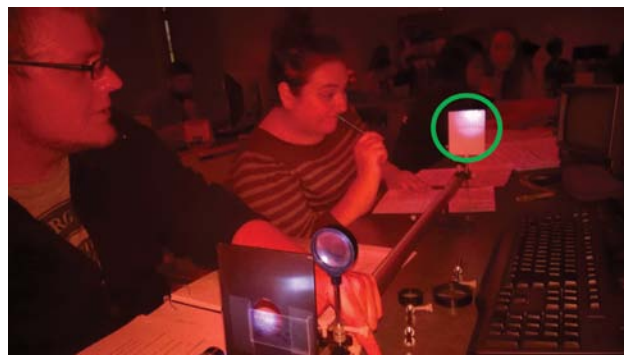
Optics can be a challenging subject for students that are not pursuing a science major. A well-organized lab exercise aids students in better understanding content and provides more opportunities to reaffirm the knowledge they obtained through lecture. To orchestrate a successful lab activity it is vital 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.<sup>1</sup> 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.<sup>2</sup> 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

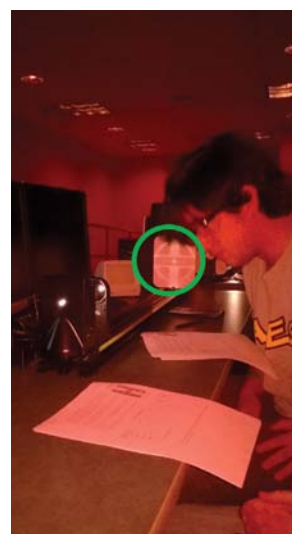


**Fig. 1. Focusing image with older equipment.** Students had a difficult time getting the image on the screen – highlighted by the green circle.

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.<sup>3</sup> Critical thinking and experimental learning<sup>3</sup> are also present by adding additional conceptual and mathematical questions.



**Fig. 2. Focusing image with PASCO equipment.** Since all the PASCO equipment is in line with the focal plane, students are able to get image on screen with ease.

## 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

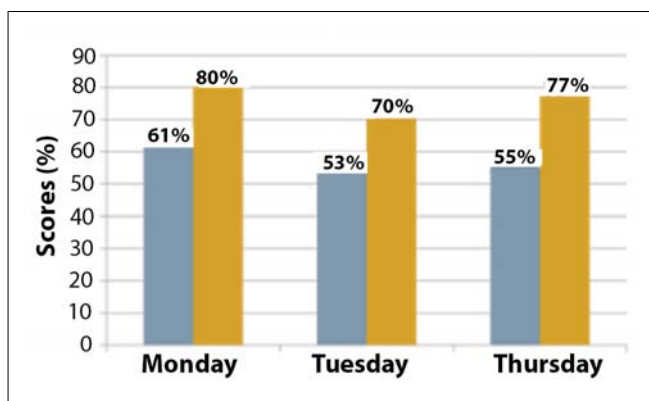


Fig. 3. Comparing lab scores.

scores were obtained during the new lab activity.

Pre- and post-quizzes were administered to assess students' retention. Pre-quizzes (in blue) were distributed before the lab activity and post-quizzes (in purple) were distributed a week afterward. The quizzes covered material from both labs and consisted of 10 questions. Qualitative analysis was recorded by the use of surveys.

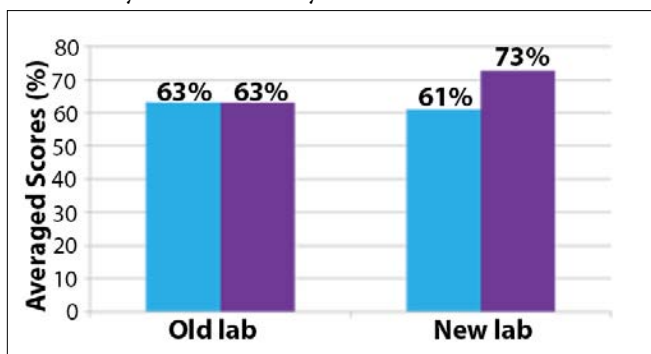


Fig. 4. Pre- vs post-quiz results.

The mean grade of the old lab was 56% compared to that of the new lab of 76%. So the new lab activity grades were

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.

## Acknowledgment

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## References

1. PASCO Labs – Exp. 12 pp. 33–36, Exp. 13 pp. 37–40 and Exp. 15 pp. 47–50.
2. ASU AST1001 lab manual (13-1 thru 13-10).
3. <http://pedagogy.merlot.org/>.

looking back through *TPT*

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- “Light-Emitting Diodes: Learning New Physics” by Gorazd Planinšič and Eugenia Etkina in the April issue, *Phys. Teach.* **53**, 210 (2015);
- “Platonic Relationships Among Resistors” by Bradley Allen and Tongtian Liu in the February issue, *Phys. Teach.* **53**, 75 (2015);
- “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);
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- “Bouncing Back From ‘Deflategate’” by Gregory A. DiLisi and Richard A. Rarick in the September issue, *Phys. Teach.* **53**, 341 (2015);
- “Who’s Teaching What in High School Physics?” by Susan White and John Tyler in the March issue, *Phys. Teach.* **53**, 155 (2015);
- “Cell Phone RF Radiation” by Wathiq Abdul-Razzaq in the April issue, *Phys. Teach.* **53**, 236 (2015).