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Communication

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Using Student-Made Posters To Annotate a Laser Teaching Laboratory

Cindy Samet*

Department of Chemistry, Dickinson College, Carlisle, Pennsylvania 17013, United States

S *Supporting Information*

ABSTRACT: Students in an advanced topics course on lasers designed posters with the goal of creating an educational laboratory space that supports teaching, learning, and outreach to the campus and community. The process of "annotating" our laser laboratory with posters was accomplished by five students and one instrument technician on a small budget of ca. $500. Employing posters as a method of peer-led teaching *and* as a way to create a user-friendly space represents an extension of previously published uses for posters in undergraduate education and thus provides an important addition to the existing education literature.

KEYWORDS: *General Public, High School/Introductory Chemistry, First-Year Undergraduate/General, Second-Year Undergraduate, Upper-Division Undergraduate, Curriculum, Communication/Writing, Laboratory Instruction, Lasers, Physical Chemistry*

■ INTRODUCTION

Posters have long been used to communicate new information at conferences and research symposia, and the "poster session" is a popular pedagogical tool at both the high school and college levels. Some posters even make their way into the hallways of academic institutions. In addition, commercially available posters conveying safety information are often displayed in teaching laboratories. Very rarely, however, are student-made posters used to explain or "*annotate*" a teaching laboratory. *Annotate* means "to make or furnish critical explanatory notes or comments."[1] Although the term is usually associated with writing assignments, such as annotating a bibliography or a calculation, posters can provide crucial information in a teaching laboratory, thereby annotating the laboratory itself. This paper describes how a laser lab at Dickinson College was designed to function as a user-friendly educational space not unlike a science exhibit at a museum. Although in our case the annotation coincided with the setup and design of the laser lab, we emphasize that the focus of this communication is on the annotation process itself and not the building of a laser laboratory.

A quick search of this *Journal* for papers with the word *poster* or *posters* in the title yielded 26 results. The early papers, between 1925 and 1941, deal almost exclusively with the making of posters for conferences.[2] The only published study in this *Journal* that discusses posters in a teaching laboratory briefly describes posters in an introductory analytical laboratory.[3] The focus of the paper seems to be on the DesignJet printer as a motivating factor for having some posters in an analytical chemistry laboratory. The posters, made by graduate students in a masters of science teaching program, explain laboratory experiments and in this way are similar to ours, but our work provides a significant extension of theirs. Another very recent study discusses the poster session as an important pedagogical tool in a second-year analytical chemistry course, but the end goal was not to design posters for display in the laboratory for teaching purposes.[4] In addition, with advances in computer technology and the ability to share documents quite easily with programs like Dropbox and Google Docs, many educators are moving toward the use of "online protocol annotation" as a way to share information among students rather than a "hard copy" such as laboratory notebooks or posters.[5] Thus, there currently seems to be no example in the chemical education literature such as that described herein, and the details provided are useful to educators in a multitude of disciplines and scenarios.

■ THE RECTOR SCIENCE CENTER LASER LAB

Dickinson College's Rector Science Center has a dedicated laser laboratory of dimensions 10 ft × 30 ft, with two laser tables and two large curtains to isolate each work area (Figure 1).

Equipment for the room was funded by a donor, and in order to complete the unfinished laboratory, it seemed that an advanced topics course about lasers with only five students enrolled would provide the perfect opportunity for the students

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Figure 1. Rector Science Center educational laser laboratory.

to learn in an active, hands-on manner. Although the class was designed as a nonlaboratory course that would meet three times a week for 50 min per session, it seemed quite likely that the six of us along with our instrument technician could complete the task within this framework. When we set out the course, we were more focused on equipping the room, but very early on the focus changed, and the students' idea to have posters as an important feature of the room took shape. Specifically, when they first saw the laser lab (which was partially equipped) and were trying to figure out what had been accomplished to date, they became frustrated, and this frustration led them to the idea of annotating the laboratory. One student commented that he "now saw so clearly why professors valued thorough laboratory notebooks", and later stated that the posters were in essence "extended laboratory notebooks that everyone could understand."

THE POSTERS

Our laser lab currently contains four separate experimental setups on two laser tables. We describe it this way for clarity, but note that one experimental setup or grouping of equipment (laser and optics) can allow for several types of measurements. Each of these four experiments has a poster associated with it. In addition, there is a fifth poster that describes for the layperson how lasers work and a sixth safety poster. In our case, each student was assigned to *one* poster. The class was divided into two groups: a pair of students who worked primarily at laser table no. 2 which housed a laser-induced fluorescence system and three who worked collectively on the three systems on laser table no. 1, which housed a modular spectrometer, a laser polarimeter, and a high-end Raman system. The first three of these experiments listed above are very close to systems described in this journal.[6−8] Each student was responsible for the final version of his own poster, but all students were involved in the peer review of each poster. Students checked each "experiment" poster by following the instructions on each to be sure all details were correct. Likewise, everyone contributed to the safety poster and the general poster about lasers. The posters were printed at the Dickinson College print center on a large format printer. Four posters are 3 ft × 2 ft, one is 30 in. × 30 in., and the safety poster is 20 in. × 20 in. The posters were hung between sheets of 1/8 in. plexiglass purchased at a local glass shop. All materials for the posters totaled approximately $500.

Each *experiment poster* describes all possible arrangements for the laser and optics and includes a photo *and* schematic of the exact equipment as it looks on the laser table. In addition, there is an explanation of the phenomenon being measured. An essential feature of our laser lab that made this correlation possible is the numbering of each component on the laser table so that it can be identified in the posters. The students devised a numbering system that would be easy to follow and would allow for growth in the room. These four experiment posters are designed to be useful to both students and instructors who desire to use the apparatus. The poster for the modular, inexpensive spectrometer[8] was designed to make it easy to understand how the equipment could be arranged to measure absorbance, Raman scattering, or fluorescence. This is extremely helpful in a laser lab that many people will use, as it enables an inexperienced or new user to see what the current configuration is and how to use it and modify it to perform a different experiment. The poster for the polarimetry apparatus[7] describes polarimetry in general and how to make a measurement using this system. The poster for the Raman Spectrometer (Ocean Optics) describes Raman scattering in general and shows each part of the system, including the schematic from the Ocean Optics Web site. The poster for the laser-induced fluorescence experiment[6] describes the phenomenon of fluorescence and details the apparatus and how to test the system with a light stick that we keep available.[9]

Finally, both the general laser poster and the safety poster are designed for the layperson, and can provide a talking point for a class or visitors who are learning about lasers for the first time. In addition, such a review can be helpful for students at all levels of the curriculum. The general laser poster is located in the back of the lab, along with a small table and chairs to foster discussion and in this way can also serve as a visual aid for a discussion led by an instructor or TA. The safety poster is located in a prominent position and is visible as soon as one enters the room. An important goal was to keep the posters relatively simple and uncluttered for ease of use, and thus, we furnished the laser lab with display binders (one on each laser table) to add a level of detail that is too much for the poster. The binders, which actually serve to annotate the posters,

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provide additional definitions relevant to spectroscopy basics and also in-depth schematics of instrument parts. In this way, the room continues to be a work in progress that can allow future students to contribute and thus experience peer-led education while ensuring that the laboratory serves users of diverse backgrounds. Finally, I note that this past semester, a class of three advanced inorganic chemistry students used the laser laboratory and reported a high level of satisfaction while using the posters and binders to learn to perform experiments. When faced with a concept or procedure that was unclear to them, they updated the binder with additional information. A representative poster is included in the Supporting Information.

EDUCATIONAL IMPACT AND OUTREACH

Quite often, laboratory spaces—especially specialized spaces such as laser labs—are underused. It is common for laser labs to be used only by the physical and inorganic chemists in a department. In addition, the modular nature of the equipment on a laser table often causes a laser lab to be disorganized and frustrating as users move and modify the arrangements on the table. Thus, transforming an underused and confusing space into one that is user-friendly automatically increases the educational impact of that space. Our annotated laser laboratory is now able to contribute to both teaching and learning in our chemistry department and beyond and, in this way, represents a useful extension of the value of posters in undergraduate education reported to date in this *Journal*. Professors who might otherwise shy away from such a laboratory can use the room to demonstrate concepts dealing with light, matter, spectroscopy, and lasers (in either a lecture-based or laboratory course for science students as well as nonscience students and even perhaps in a first-year seminar). In addition, the peer-led teaching accomplished in the posters can continue to set an example for future students and, in fact, can continue to provide opportunities for student-led education with the use of display binders, which may be expanded over time. Such a space is also valuable for community outreach events and for visitors, such as high school students working on a science fair project. Most important, our laser laboratory scenario translates well to *any* teaching laboratory, especially one with instrumentation. For example, a poster on gas chromatography would be beneficial at the GCs that are used by many students in a typical organic chemistry laboratory course. Central instrument laboratories commonly shared and often showcased to visitors and prospective students could greatly benefit on several levels from such annotation and, thus, be of additional value to the institution. Finally, annotating *research* laboratories in this way could greatly aid both faculty and students in the effort of training new students. Thus, in myriad ways poster and binder assignments provide students with a useful experience and the end products have the potential to transform laboratory spaces into aesthetic exhibits to be understood and enjoyed by many.

ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available on the ACS Publications website at DOI: 10.1021/acs.jchemed.5b00658.

Representative poster (PDF)

AUTHOR INFORMATION

Corresponding Author

*E-mail: samet@dickinson.edu.

Notes

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