Developing technical and soft skills in an introductory optics course

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ABSTRACT

The laboratory-based Optics course was envisioned by the Department as a bridge to upper-level laboratory courses, thus students must display increased initiative and collaborative skills. In recent years since the pandemic began, it appears student initiative has declined. Activities within the course have been refined and new ones developed to build technical skills such as problem solving and optical design. New activities have been developed as well to build soft skills, for example, self-awareness, time management and adaptability. The new activities appear to improve soft skill development. Technical skill development was positive, however it is not clear that the revisions resulted in a significant improvement.

Keywords: optical design, introductory optics, laboratory course, soft skills

1. INTRODUCTION

The course "Optics" is a one credit, laboratory-based course in introductory optics for physics majors. It is a required course for the major and follows the two-course introductory sequence (Mechanics, Electricity and Magnetism). Since reopening to in person classes in fall 2021, Optics has been offered four times. The recent semester (spring 2023) had an enrollment of three students, which is typical. We were able to incorporate new activities and continue with certain revisions developed during the 2020 -2021 academic year, which was fully online.[1]

1.1 Motivation

The return to an in-person Optics course was challenging due to the physics majors being at different points in their coursework. This resulted in having to offer the course for one student in both semesters of 2021 - 2022, and again in fall 2022. Because of the low enrollment, the faculty member must teach it as a voluntary addition to a full teaching load. Thus, students were expected to carry out the lab activities somewhat as an independent study. During this time, the professor noticed the students were routinely late with submitting assignments, and repeatedly extended deadlines. Pandemic related stresses on students continued and affected their academic performance. Researchers have noted negative effects of the pandemic on student wellness, and also learning in physics labs.[2,3]

As our majors move from this intermediate-level course, which we envisioned as a bridge to upper-level physics laboratories, they must have increased initiative and a higher ability to collaborate with other students as well as the faculty. Given student initiative has declined in some ways, the professor attempted to encourage development of soft skills such as collaboration, critical thinking, and self-initiative with new activities in Optics.

To improve the students' technical skills and understanding of the concepts, many of the supporting materials from the online year were incorporated into the course this semester via the learning management system.[1]

1.2 Course Topics

Course topics included geometric optics and physical optics; specifically reflection, refraction, lenses, diffraction, interference, and polarization. Students investigated some basic applications of geometric optics by building a simple refracting telescope. Each student developed her own topic for an independent project, which was first proposed about four weeks into the semester. The experiments were completed in the last few weeks of the semester.

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2. DEVELOPING TECHNICAL SKILLS

2.1 Pre-lab Assignments

To improve understanding of the concepts prior to each lab meeting, the professor included materials that were developed for the online version of the course. The materials included simulations, links to existing videos and slideshows with narration by the professor. Table 1 lists the materials by topic with links to materials available on the internet.

Table 1. Pre-lab materials and assignments listed by topic

Topic	Material	Links
Reflection	Videos	https://youtu.be/mK8_sIeXp7o Plane mirror
Refraction	Slides, video	https://youtu.be/ON1QGqB6vxg Snell's law
Lenses	Slides, simulations[4]	https://ophysics.com/l12.html Lenses
Diffraction/Interference	Simulations[5], video	https://www.compadre.org/Physlets/optics/ex38_2.cfm Diffraction physlet

2.2 Data presentation and analysis

In terms of improving data presentation and analysis skills, early summary reports were submitted in two parts. The students submitted tables and graphs of data, along with calculations for the refraction and polarization activities. The professor gave them feedback before the students wrote full reports which added sections on background information, description of the experiment, and a discussion of the results. Although students in Optics had previously completed two introductory physics courses with laboratories, they did not begin using the skills learned in that course immediately with the optics assignments. For example, their graphs of data lacked error bars and graph axes were not labeled with the plotted quantity and/or units. After submitting two reports where students incorporated the feedback, by the third activity they included these details on the first submission.

2.3 Dovetail rail set up

Most of the experiments were done using equipment from an introductory optics educational kit. We did use a dovetail rail setup to make a demonstration of real images formed by a convex lens**.** Each student had some time to adjust the setup and make measurements. Though this is a brief introduction, they will work with research grade optical components in their junior and senior year laboratories. It is thought that some familiarity will lead to students showing increased initiative in the next lab course.

3. DEVELOPING SOFT SKILLS

Within this course, students were previously encouraged to develop soft skills such as collaboration, critical thinking, and initiative. In general, the students receive very limited instructions on how to proceed once they have familiarized themselves with the concepts. They are asked to come up with their own experimental plan to test a concept such as Snell's law, $n_1 sin\theta_1 = n_2 sin\theta_2$. Following the professor consulting with them on the plan if they want it, the students then carry it out. However, with the return to in-person classes in fall 2021, students appeared to struggle with this method, regularly needing extensions for assignments. Due to the time constraints, we were not able to include additional labs on optical fibers and magnification of a simple telescope.

After participating in a workshop related to building soft skills in STEM courses (sponsored by Fayetteville State University[6]), it was determined that modifying components of the independent project would allow for development of several soft skills including self-awareness, communication, planning, being proactive, time management, and adaptability. From the workshop, it became clear that the soft skills, which students most need to develop, should improve simply by a stronger focus on time management.

3.1 Independent Project

Each student is required to complete an independent experimental project. Students propose a topic, and pending instructor feedback and approval, carry it out independently during the last 2 - 3 weeks of the semester. Students may begin working on the project as soon as possible, but at minimum the last 2 sessions of the semester are set aside for work on the project. Students submit a written report on their project as the last regular assignment of the semester.

3.2 Revised Assignments for the Independent Project

The draft of the proposal has been modified to ask for a first attempt at the timeline. Students will receive feedback on both the content of the proposal and the proposed deadlines. They will then need to submit a finalized timeline and possibly a revised proposal if necessary.

New components to the assignment include a timeline of all activities related to the project and a reflective essay to concentrate on the students' self-evaluation of her skill development during the process. The prompt for the reflective essay currently reads as follows:

> Write a short reflection on this experimental process, specifically related to completing this project and your growth in terms of professional skills. Also, comment on your reactions to any critical feedback and how you were able to show flexibility in making changes based on that feedback.

The timeline assignment asks students to submit a table, which lists the following: activities to be completed, expected completion date, and the person responsible (student or faculty member). The timeline does help students manage their time more efficiently and promote self-motivation for completing the project. Thus far, the soft skills the students feel they have strengthened are time management and troubleshooting.

4. CONCLUSIONS

Changes to the Optics course were implemented following the return to in-person classes at Spelman College. The purpose was to help develop technical and soft skills in the Physics majors who take this required course. Time management was improved by the timeline assignment that students developed for themselves. Given the feedback received on the proposal, students also stated their troubleshooting skills improved. The spring session was able to add back a lab activity on the telescope, which shows that the class overall proceeded more quickly through the labs than the initial post-pandemic sessions. It appears that technical skill development was positive over the semester. However, judgement should be withheld until we see how the students perform in the next lab course, Advanced Lab.

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