Annual Assessment Report

Department of Physics

31 May 2022

The Department of Physics met on May 10, 2022, for our annual assessment meeting. In attendance were all members of the department: Julie Gunderson, Damon Spayde, John Steward, Todd Tinsley, and Ann Wright.

Our agenda covered three main topics related to our Student Assessment Plan:

(1) Reflecting on the 2022 capstone exam experience.
(2) Discussing the new ways that we developed computational skills in the 2021-2022 academic year, and what that should look like in 2022-2023.
(3) Assessing our students' technical skills when designing and completing laboratory projects in physics.

The Physics Capstone Exam (Associated with Department Learning Goal #1)

In 2020, the first year of our revised student assessment plan, the annual assessment meeting for our department resulted in a redesign of our capstone exam that brought it more in line with our newly adopted learning goals. This spring marked the second time we have administered the new capstone exam. Last year's assessment report states:

> *The general consensus of the department was that the revised capstone exam appears to be much better aligned with the DLG1 rubric. While minor revisions will probably occur on an annual basis, it seems likely that the new structure of four content area parts with two questions will be preserved going forward.*

After reviewing this year's direct assessment data and feedback from students on their exit interviews, the department concluded that we are still happy with the new format for the capstone exam and see no evidence to change the format.

As in previous years, we continue to see that students demonstrate the most mastery over the material associated with the upper-division courses offered in the *same year* of the capstone exam. For example, this year the physics department offered *PHYS 430 Quantum Mechanics* and *PHYS 420 Electrodynamics*, and last year we offered *PHYS 470 Thermal Physics* and *PHYS 480 Classical Mechanics.* As Figure 1 shows, this year students demonstrated the most mastery over *Quantum Mechanics* and *Electricity & Magnetism*.

There was some discussion over the benefits and drawbacks of splitting the exam up in different ways, for example, so that students can take half of the exam as juniors and half as seniors. We are confident that testing students only over the material they focused on in the last year would improve the overall senior capstone grades. However, we ultimately decided this would make connections between and synthesis of the different content areas less apparent for students, defeating the catalog's stated purpose of a

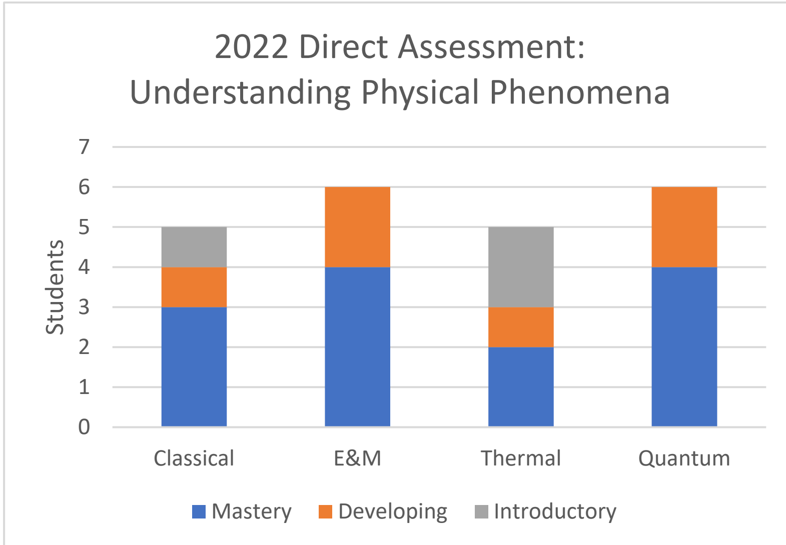

Figure 1. Direct assessment data from the 2022 Senior Capstone Exam in physics. There are four sections to the capstone exam: Classical Mechanics, Electricity and Magnetism, Thermal Physics, and Quantum Mechanics. Based on their responses in each content area, students are scored as showing an introductory understanding of the material, developing mastery over the material, or demonstrating mastery over the material. One student only took portions of the exam because they are an interdiciplinary studies major, resulting in the total number of students being one less in sections on Classical Mechanics and Thermal Physics.

senior capstone experience "for the student to integrate and synthesize the various aspects of the subject matter studied within the major."

Computational Skills (Associated with Department Learning Goal #2)

The subject of our 2021 Assessment Report was the assessment of our department's second learning goal:

> *Upon successful completion of the requirements for the physics major, students will be able to apply the analytical, numerical, and computational skills necessary to solve complex problems in physics.*

The evidence from our direct and indirect assessment suggested that an opportunity to improve was in helping students develop computational skills. In our 2020-2021 Assessment Report we wrote:

> *The results regarding computational skills indicate an area for potential curricular improvements … Going forward, the department should discuss what computational skills to develop, in what context they should be developed, and then make the time and materials necessary to develop them.*

A context within which it is natural to develop many computational skills is our PHYS 305 Vibrations and Waves course. This class is required of all majors, is a corequisite or prerequisite for the 400-level courses where students master these skills, and immediately follows the introductory physics sequence where we introduce students to scientific programming. In the fall of the 2021-2022 academic year, Todd Tinsley used lecture days and homework assignments in Vibrations and Waves to develop skills in:

- The LaTeX scientific typesetting language,
- The matplotlib python library for creating scientific plots,
- Numerically solving differential equations with Euler's and the second-order Runge-Kutta method,
- The LinAlg library of NumPy to diagonalize matrices and perform other matrix-related operations,
- Performing discrete Fourier transforms with student-authored code and by using the native ability of NumPy.

The department discussed how we could most appropriately build upon these skills for mastery in later courses and how to make sure a common set of skills were taught at the developing stage no matter who is the instructor. We decided that a first step would be to document the ways that each instructor has been developing computational skills in their courses and what resources they are using to do that. We have set up a folder on our departmental SharePoint site for this purpose. The department will use this documentation next year to identify a common set of skills we wish to develop at the intermediate level and how students will demonstrate mastery in later upper-division courses.

Assessing Technical Skills (Associated with Department Learning Goal #3)

Our 2020 Student Assessment Plan calls on the department to assess our third learning goal this year. Our third department learning goal reads:

> "Upon successful completion of the requirements for the physics major, students will be able to **apply the technical skills necessary to design and complete laboratory projects in physics**."

Julie Gunderson performed the direct assessment of this learning goal by applying the department's Electronics Project Rubric (Appendix C of our Student Assessment Plan) to her fall PHYS 340 students. As a measure of the students' abilities to design and complete laboratory projects, the rubric scores their project in three areas:

- Whether or not the **idea** is unique and clearly articulated,
- Whether or not the **implementation** of the idea functions as expected, builds upon and is reflective of the material covered in class, and
- Whether the final **circuit diagram** for the project is presented clearly using standard notation.

The direct assessment data on the six students in the fall 2021 Electronics course are found in Figure 2. The data show that all six students were either developing or had achieved mastery in all three categories of the rubric. Electronics students represent a wide array of laboratory experience and maturity because the course generally draws an assortment of sophomores, juniors, and seniors. Therefore, the department was particularly pleased to see no students at the introductory stage of the learning goal.

With such small numbers of students, we feel it is inappropriate to read too much into the fact that two more students achieved mastery in the implementation of the project than in the formulation of their idea and clarity of their circuit diagram. However, our conversation did note that *design* of laboratory

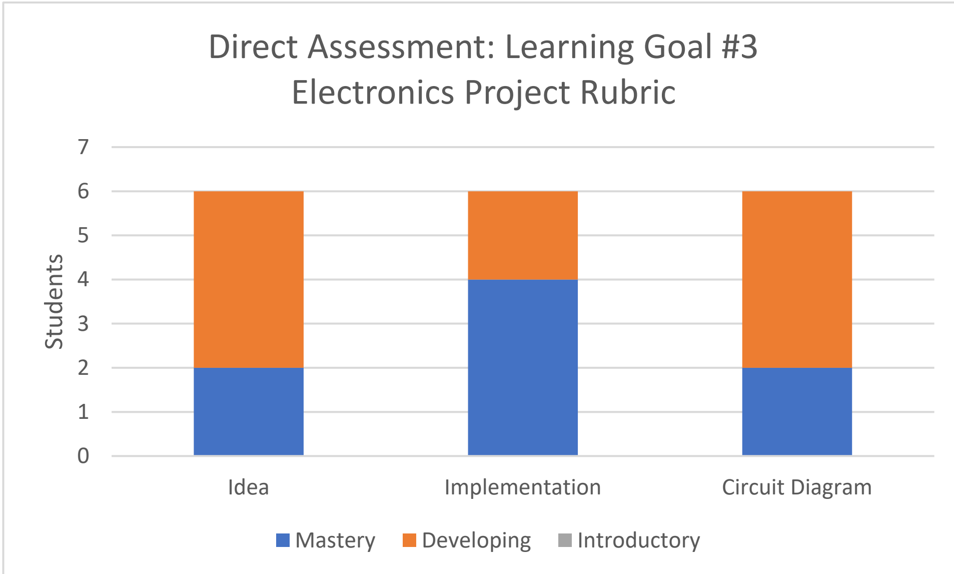

Figure 2. Direct assessment data for the department's third learning goal, technical skills in the design and completion of laboratory projects in physics. These data cover the six students who took PHYS 340 Electronics in the fall of 2021.

projects (best represented by the *idea* criterion on the rubric) is generally more challenging for students that the *completion* of laboratory projects (best represented by the *implementation* criterion). This conclusion is supported by indirect assessment data collected from student responses on their annual exit interviews (Question 8 of Appendix F of our Student Assessment Plan).

Due to the small numbers of respondents to our anonymous exit interview each year, we pooled the responses for three years between 2020 and 2022 and display those data in Figure 3. Over the last three

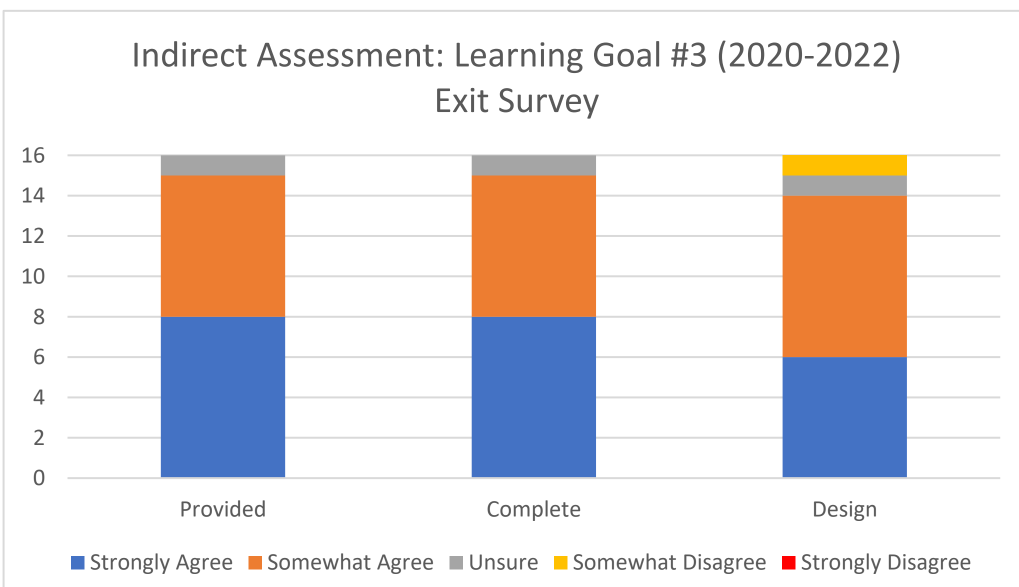

Figure 3. Indirect assessment data collected over the last three years on question 8 of the Student Exit Survey. The question asks students to indicate their level of agreement/disagreement with positive statements about whether they were provided with adequate laboratory experiences, whether their skills necessary to complete laboratory projects has developed or improved, and whether their skills necessary to design laboratory projects have developed or improved.

years, we see that students overwhelmingly agree with the statements that they developed the skills necessary to complete and design laboratory experiments in physics, but the strength of that agreement is greater for completion.

In light of the evidence, the department's conversation focused how we might move more students from the developing stages of the criteria in the third learning goal to the mastery stages, particularly for weaker students. The department lifted out two strategies that might be helpful here. The first was for instructors to make sure that *timeliness* is a part of any scaffolded approach to the electronics project. Several of this year's electronics students struggled to make good use of their class time, which resulted in them being less able to show sufficient mastery over facets of their projects. The second strategy was for instructors to consider using a "complete and expand" approach to course projects. In this model, students would complete an existing guided lab activity, and then spend a week expanding on the activity to integrate, for example, more functionality or other course material. By paring down the scope of the project, weaker students may have a better chance to develop and show mastery over the completion and design of laboratory projects.

The discussion also prompted the department to revise the Electronics Project Rubric so that the text for "Developing" under the "Idea" criterion included those students whose idea is unique but only reasonably well-articulated.