Annual Assessment Report: Department of Physics

2 June 2021

Introduction

The physics department held its annual assessment meeting on Tuesday, 27 April at 12 PM. In attendance were Julie Gunderson, Damon Spayde, John Steward, and Ann Wright. (Todd Tinsley was on sabbatical this semester and did not participate in the meeting.) There were two primary topics for this assessment meeting: a discussion of the revised capstone exam in light of last year's assessment of Department Learning Goal 1 (DLG1) and the assessment of Department Learning Goal 2 (DLG2). The mechanics of assessing DLG2 were discussed during the meeting; the collection and analysis of data were carried out after the meeting. The results of that analysis were discussed via email and are incorporated into this document. (Direct assessment of DLG2 could only be carried out after all the grades for the semester were finalized which happened several weeks after the assessment meeting.)

Capstone Exam Revision and Department Learning Goal 1

During academic year 2019-2020, the department completed direct and indirect assessments of DLG1:

> *"Upon successful completion of the requirements for the physics major, students will be able to demonstrate an understanding of physical phenomena and the models that describe them."*

The direct assessment of DLG1 is determined by student performance on the physics capstone exam. It became clear at last year's assessment meeting that the questions asked on the capstone exam were not well aligned with the rubric adopted to score them (see Appendix A of the Student Assessment Plan for a copy of the capstone exam rubric). At that time we pledged to update the exam to bring it in line with DLG1 and the rubric. Over the course of the 2020-2021 academic year the department discussed how to best accomplish this goal. It was ultimately decided to rewrite the exam to consist of four parts — one for each of the four main content areas covered by the rubric: classical physics, electromagnetic theory (EMT), thermal physics, and quantum physics. Each part contained two questions specific to that subject: one written at the introductory level such as could be answered by a student completing the appropriate introductory or sophomore-level course and one written at the upper-level that would require completion of the appropriate 400-level course. If a student could answer the former question but not the latter, then they would have demonstrated an "Introductory" understanding of the material. If a student could answer both, then they would have demonstrated "Mastery". A "Developing" understanding would fall somewhere in between.

The department scored performance on the revised capstone exam against the DLG1 rubric, recording the number of students who achieved each category of understanding (Introductory, Developing, or Mastery) in each subject/exam part (Classical, EMT, Thermal, and Quantum). The results of this scoring

are shown in Figure 1. It was observed that not all of our departing students were able to demonstrate even an Introductory level of understanding in all content areas, as shown by columns in the figure with less than ten total students (the number who took the exam in the current academic year). The proximity-in-time effect discussed in last year's assessment report is clearly present as well. Thermal and classical physics were both taught this academic year whereas EMT and quantum were both taught last year.

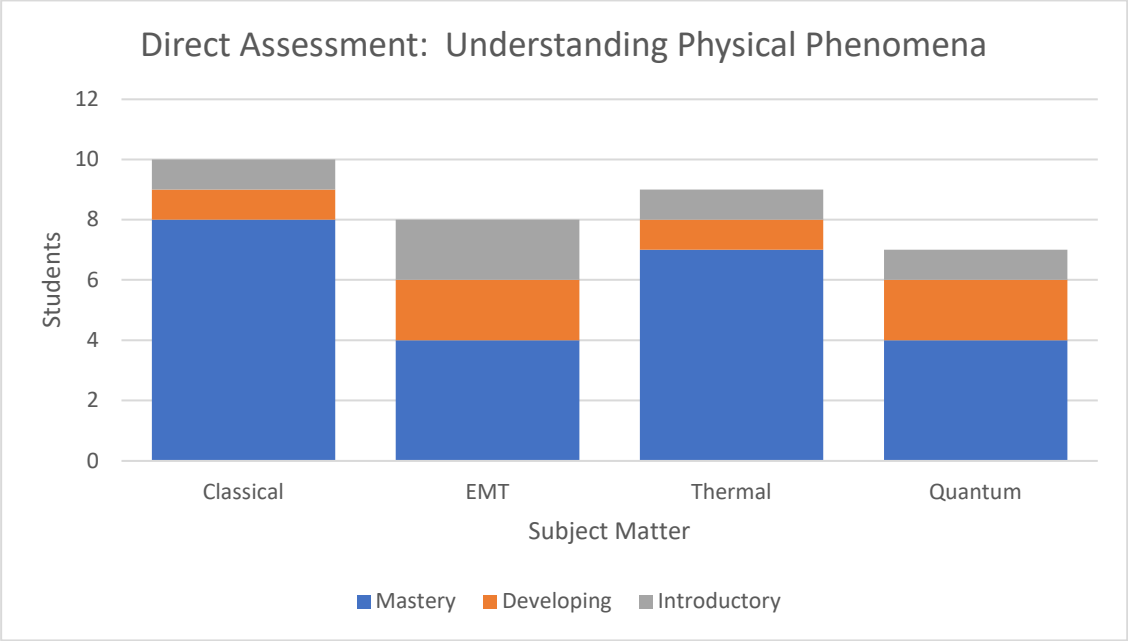

Figure 1. This stacked bar graph displays the results of the department's direct assessment of physics students' understanding of physical phenomena (DLG1). Each bar corresponds to an instructor's tally of the number of students achieving each category (Mastery, Developing, or Introductory) in each of the four major content areas (Classical, EMT, Thermal, and Quantum) tested on the revised capstone exam. A total of ten students took the exam but the total number of students in a given bar may be less than ten. This occurs when one or more students fail to answer either the introductory or upper-level question in a content area; i.e. they do not demonstrate "Introductory" understanding of the content.

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.

Assessment of Department Learning Goal 2

The assessment cycle laid out in the department's student assessment plan required an evaluation of the DLG2 in academic year 2020-2021:

> *"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."*

Direct Assessment

The physics department developed a rubric for assessing DLG2 in the so-called "Big Four" courses: PHYS 420 Electrodynamics, PHYS 430 Quantum Mechanics, PHYS 470 Thermal Physics, and PHYS 480 Classical Mechanics. These four content courses are required for all graduating physics majors. (PHYS 430 is the only required big four course for chemical physics majors; PHYS 420 and PHYS 470 are electives in that major.) The rubric is Appendix B in the Student Assessment Plan and is attached to this report as reference.

During the 2020-2021 academic year, only PHYS 470 Thermal Physics and PHYS 480 Classical Mechanics were offered during the fall and spring semesters, respectively. The instructors of those courses (Spayde and Wright) were asked to provide a tally of the number of students in each category (Introductory, Developing, or Mastery) for each of the three criteria (Analytical, Numerical, and Computational). There were 18 total students enrolled in PHYS 470 and 16 in PHYS 480. The results of the direct assessment can be found in .

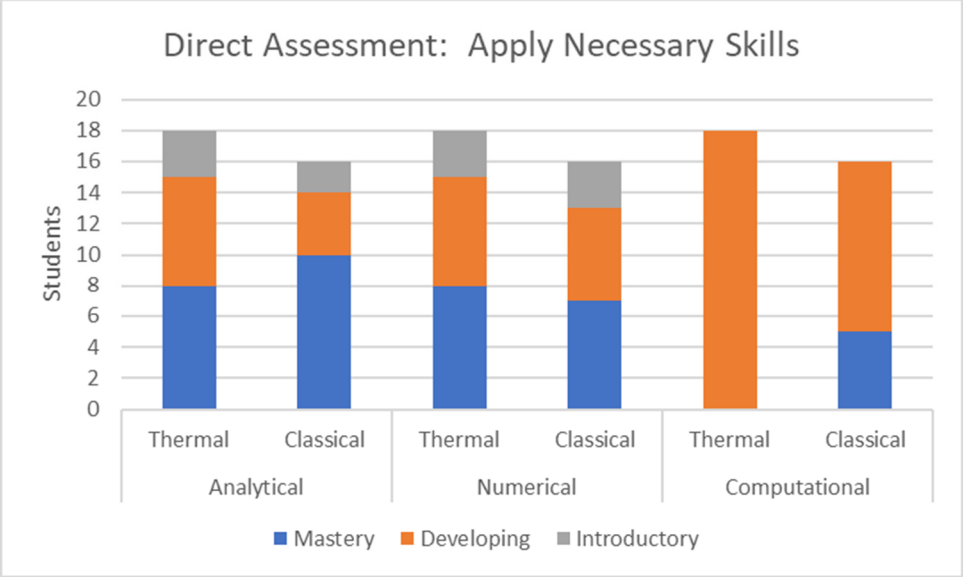

Figure 2. This stacked bar graph displays the results of the department's direct assessment of physics students' ability to apply necessary skills in solving complex problems. Each bar corresponds to an instructor's tally of the number of students achieving each category (Mastery, Developing, or Introductory) for each of the three skills (Analytical, Numerical, and Computational) in each of the two courses offered in the 2020-2021 academic year (PHYS 470 Thermal Physics and PHYS 480 Classical Mechanics).

Indirect Assessment

The physics department administers an exit survey to departing, via graduation or enrolling in a dual-degree engineering program, students using Microsoft Forms. A copy of the exit survey can be found in Appendix F of the Student Assessment Plan. Question 7 of the survey asks students to indicate their level of agreement with a set of three positive statements that the physics curriculum has helped them to develop or improve their analytical, numerical, and computational skills: Strongly Agree, Somewhat Agree, Unsure, Somewhat Disagree, Strongly Disagree, or N/A.

It was determined that ten departing students were eligible to participate in the exit survey. Of those ten students, one was departing early due to entry into a dual-degree engineering program and the remaining nine were completing their degrees. Nine of the ten students were physics majors, and the

tenth was an interdisciplinary studies major with a significant physics component to it (that student had completed all of the "Big 4" courses). Survey response was solicited via emails to the departing students. Several reminder emails were sent out as the end of the school year approached and passed. Despite these efforts, only four of the ten departing students completed the exit survey. The quantitative results from the pertinent portion of the exit survey can be found in .

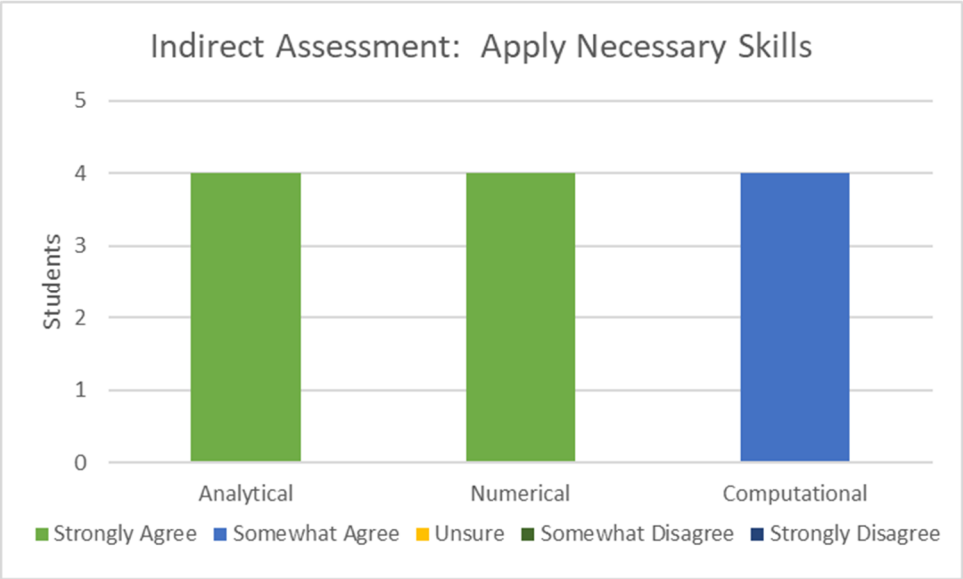

Figure 3. This stacked bar graph displays the results of the department's indirect assessment of physics students' ability to apply necessary skills in solving complex problems. Each bar corresponds to one of the three assessed skills (Analytical, Numerical, and Computational) and indicates the number of students who chose each level of agreement (Strongly Agree, Somewhat Agree, Unsure, Somewhat Disagree, or Strongly Disagree) with a positive statement regarding the improvement of that skill through the study of physics. Only four of ten departing students completed the exit survey.

Use of Evidence

The 2020-2021 assessment results for DLG2 generally indicate that the physics curriculum has aided students in the development of their analytical, numerical, and computational skills, as evidenced by the data in (instructor assessment of skill development). Furthermore, it appears that student perception of skill development is in agreement with instructor perception, as evidenced by .

Instructor assessment of analytical and numerical skills in the classroom indicates that nearly half of all students had achieved mastery. Of the remaining students across the two assessed courses, no more than three were found to have only achieved the introductory level for a skill. The results regarding computational skills indicate an area for potential curricular improvements. A clear minority of students achieved mastery in computation with the remainder still developing. This result is perhaps unsurprising. Computational skills are introduced at a very basic level in the introductory physics sequence (PHYS 235 and 245 Physics I and II) but there is no other place in the curriculum where there is a formal development of those skills. Student perception appears to agree with instructor assessment — all four students responding to the exit survey indicate they only somewhat agree that computational skills were developed. This is in contrast to analytical and numerical skills where all four students strongly agree those skills were developed. 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.