Annual Assessment Report
Department of Physics
15 May 2019

Rubric

As part of the 2018 Fall Faculty Conference, the Department of Physics met to begin the process of formalizing our informal discussions of our students' performance on our capstone exam. Our capstone involves taking a departmental exam that emphasizes problem solving and covers material throughout a student's physics course history. We considered how the capstone assesses what students have learned over their 3-4 years in our program.

The department began by deciding on criteria that connected a student's capstone exam to the third learning goal for our department:

3. *To provide physics majors with an in-depth study in the field of physics.*
    a) *A clear understanding of the experimental basis of all fundamental physical theories. They should understand the major theories and be able to explain how they follow from experimental results.*
    b) *A panoramic view of the field of physics with enough detail to enable them to easily make connections with new information in physics, and thereby more readily assimilate new information.*

We believe that for a faculty member to be able to assess whether a student has a clear *understanding of physical theories* based on their capstone work, those students needed to identify core physics principles. To assess whether a student has a clear understanding of *how physical theories follow from experimental results* based on their capstone work, those students will need to analyze and draw conclusions and to apply mathematics appropriately. And to assess from their capstone work whether a student has a *panoramic view of the field of physics* with enough detail to enable them to easily make connections with new information in physics, those students would need to communicate well, and the **rubric would need to be general enough to apply to any of the subdisciplines tested on the exam**.

A copy of the draft rubric for our senior capstone exam can be found in Table 1.

At two later department meetings (September 25, 2018, and October 9, 2018), we applied the rubric to student capstone exam work to flesh out the rubric and assess where those students would place.

Upon reflection from that exercise, we found that the rubric was *not* particularly helpful. We suspect that our capstone could be better connected to our learning goals or that our learning goals need updating. We included a discussion of both our capstone and our learning goals in the self-study for our program review this year, and in response to the consultant's feedback, we have begun rewriting our learning goals.

Student Assessment Plan

Though our Student Assessment Plan was written in 2007, the Department of Physics believes that it is appropriate for our current learning goals, is accompanied by an appropriate map of our curriculum onto our current learning goals, and that it calls for the collection of appropriate data given our current learning goals.

The current plan does not include this year's work on the capstone exam rubric. As mentioned in the previous section, our department does not feel that the rubric in its current form is an appropriate instrument for direct assessment. We continue to collect other forms of direct assessment, including senior capstone work and faculty feedback on that work.

A more fitting time to revise our Student Assessment Plan will be next year as our department incorporates what we learned from our program review this year into the plan.

Response to Assessment Committee's Targeted Feedback

The Department of Physics would like to thank the Assessment Committee for the thoughtful feedback on our *Narrative of Strength* from last year. We, too, are proud of our plan to improve student learning generally and in the introductory *Workshop Physics* sequence specifically. We also appreciate the advice that our narrative should better capture that the changes we implemented derived from direct evidence.

Our department formally assesses student learning in introductory physics with exams, homework, and content-specific pre- and post-testing (the *Force Concept Inventory*, or FCI, for the first semester and the *Conceptual Survey of Electricity and Magnetism, or CSEM,* in the second semester). After two years of fully-implemented *Workshop Physics*, results on the FCI show that students in *Workshop Physics* demonstrated similar gains as students in our first semester of algebra-based physics *PHYS 210* but less gain compared to students in first semester of calculus-based physics *PHYS 230* taught in the conventional lecture and lab format. Gains on the CSEM for the second semester of workshop physics (*PHYS 245)* were consistent with those of the second semester of calculus-based lecture/lab format physics (*PHYS 240*) and significantly greater than the second semester of algebra-based lecture/lab physics (*PHYS 220*).

In 2015 when the first section of *Workshop* physics was taught, the new class didn't just change the format for learning physics but also the content. The department is concerned that the assessment instruments, particularly the FCI, might be most sensitive to the content and textbook language rather than the format. Given that our current textbook, *Matter &* Interactions, departs most from a conventional text in the first semester material, this might explain why workshop sees comparable gains in the second semester but not in the first. This observation is consistent with that reported in Physics Education Research literature for physics courses taught with *Matter & Interactions* and assessed with the FCI.[1,2] We raised this in our program review this year. Our external consultant, Dr. Jan Tobochnik,

[1] Caballero, et al., "Comparing large lecture mechanics curricula using the Force Concept Inventory: A five thousand student study", *AJP* **80**, 638 (2012); doi:10.1119/1.3703517.

[2] L. Ding and M. Caballero, "Uncovering the hidden meaning of cross-curriculum comparison results on the Force Concept Inventory", *Phys. Rev. Spec. Topics - PER* **10**, 020125 (2014). doi:10.1103/PhysRevSTPER.10.020125.

pointed out there are other factors for choosing a text than FCI gains (e.g. applicability to our different audiences, exposure to computation) and that the course has other positives than teaching content (e.g. critical thinking, working in groups). Tobochnik concluded:

> "Thus, there are many issues here. My recommendation is that the department do an assessment of the course, after they have clearly identified the Department learning goals as well as their learning goals for this course."

Spurred on by this advice, the department began rewriting our learning goals at our May departmental retreat, and we look toward fleshing these out next semester.

Department of Physics Capstone Draft Rubric

Category	Exemplary	Competent	Basic
Identifies Core Principles	Accurately identifies knowns and unknowns. Uses that information to articulate effectively an approach to the problem and selects appropriate formulae.		
Analyzes & Draws Conclusions	Applies appropriate simplifying assumptions to solve the problem. Uses strategies to assess the reasonability of the answer, e.g. carrying units throughout the problem, dimensional analysis, comparison to known values.		
Applies Mathematics Appropriately	Achieves a correct result by applying appropriate mathematical reasoning. This can include mathematical concepts like algebra, calculus, statistics, and differential equations, but it also includes scientific reasoning skills like the ability to read and understand graphical displays of data.		
Communicates Well	Clearly articulates their thoughts by presenting a neat and organized solution that shows steps, provides explanations throughout, and utilizes appropriate notation.		

Table 1. A draft rubric for evaluating student work on the capstone exam for the Department of Physics.