Competency-based Lab Skills Assessments: What have We Learned and Where are We Going?

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As part of our overall assessment of program learning objectives, our department has paid careful attention to the types of skills and abilities we expect our students to learn in laboratory courses. Examples of critical lab skills include measurement and error analysis, data analysis and programming skills, and use of diagnostic equipment such as voltmeters and oscilloscopes. A team of physics faculty have mapped out where and when certain skills will be taught, and competency-based lab skills exams have been developed to assess student learning. This poster summarizes results of one such assessments, discusses revisions of these assessments, and how results highlight the need for curricular change in certain areas. As an example of using assessment to close the loop, we will describe our latest curricular revision efforts which include a proposal to re-structure our intermediate laboratory courses.

Laboratory Skills

Ongoing assessment of departmental laboratory courses led our department to create a list of seventeen lab skills that are essential for physics majors. Examples include:

1. Keeping a lab notebook
2. Use of machining tools and metal working equipment
3. Designing an experiment to test a specific hypothesis
4. Interfacing equipment with computers/technology

Lab Skill	Beginning Level	Intermediate Level	Mastery Level
#4: Hook up practical circuits.	Connect jumper wires, light bulbs/ resistors and batteries (and possibly capacitors and other passive components) correctly.	Use a breadboard and understand circuits with diodes, capacitors, transistors, and op-amps. Understand basic digital circuits. Be able to solder wires.	Trouble-shoot a circuit. Design useful circuits such as current amplifiers, and feedback circuits. Use CAD software (Eagle) to design, layout, and manufacture a proto-board. Advanced digital circuits like FPGAs.
Courses	PHY 205, 206, 302	PHY 303	PHY 303, 581, 582

Table 1: A single lab skill, evidence of student mastery at three levels, and courses in which this skill is learned/practiced.

Competency-based Exams

Intermediate level lab courses (PHY 302, 303 and PHY 332) feature competency-based lab skills exams designed to assess and to help teach selected laboratory skills. Students may re-take these exams as many times as necessary to pass them – successful completion is required to pass the course, and we track how many attempts are necessary for each student.

Distance [cm]	Intensity [mW/cm²]
0.5	92.5
0.5	97.3
0.5	105.2
1	149.3
1	155.7
1	180.3
2	222.3
2	244.5
2	240.1
2.5	310.2
2.5	330.5
2.5	303.1

Statistics Competency Exam

Students have 10 minutes to:

1. Calculate mean values and standard deviations for the data provided.
2. Plot the mean value of intensity vs. distance.
3. Add appropriate labels to the axes.
4. Add y error bars using the standard deviation calculated.
5. Add a regression best-fit line to the plot to determine the best fit slope and intercept.
6. Estimate the value of the Chi-Squared statistic for the goodness of fit.

Figure 1: The Statistics Competency Exam from PHY 332 (Physical Optics Lab)

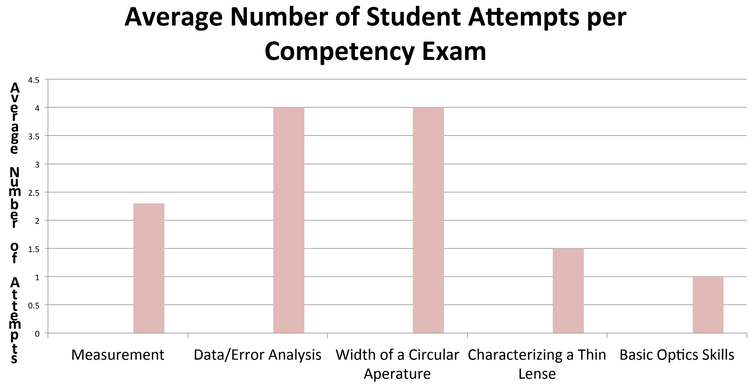

Figure 2: The average number of attempts on each competency exam in PHY 332 required for successful completion (2014+2015)

Current Lab Curricula

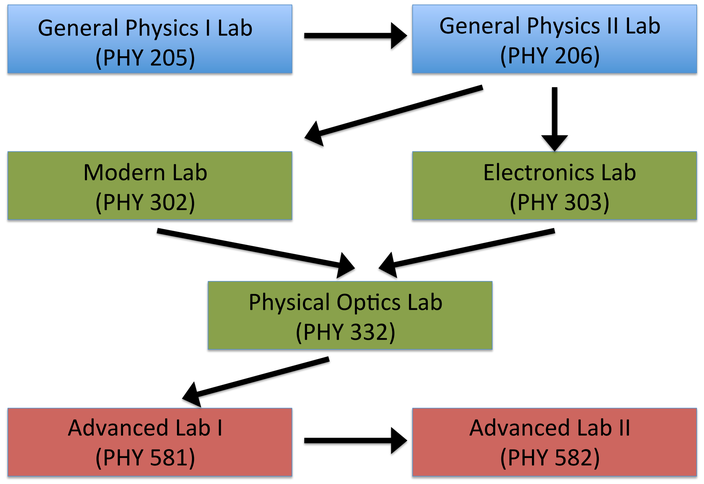

Figure 3: Physics Department Laboratory Sequence (introductory, intermediate, and advanced courses).

Lessons Learned

Skills-based competency exams have given us a powerful method of assessing student mastery of laboratory skills. They have been useful in several ways:

1. Data allows for continual revision of courses in response to student learning (error analysis/statistics is problematic)
2. Robust assessment of student learning
3. Pushed a 100% success rate (failure is **NOT** an option …)

Future Plans

This work has led to a major data and assessment-based revision of our lab curricula. Proposal in the works:

1. New Research Methods course in the intermediate lab sequence
2. Re-organizing intermediate lab courses, especially modern physics
3. Senior capstone project in lieu of advanced lab II

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