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Practical Assessment of Basic Skills in High-Enrollment Biology Lab Courses

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Extended Abstract

Authentic assessment in undergraduate biology courses should measure learning of widely applicable skills and concepts that benefit the student outside of the course in which that material is learned (Gulikers et al., 2004). This is particularly true in laboratory courses, which can provide the real-life, marketable skills required to engage in research and work in a laboratory setting. Practical assessment that directly tests physical laboratory skills, such as pipetting and microscope use, is widely accepted to be the most valuable measure in this regard (Winnett-Murray and Hertel, 2013). Despite the value of this approach, the logistical challenges involved can make lab practical assessment difficult to implement in a meaningful way. Lack of time, equipment, and feasible rubrics for measuring lab skills are problems that are compounded in high-enrollment lab courses with a low instructor to student ratio. Here we present two lab practical exercises that measure routinely-used skills in the molecular biology laboratory. These exercises are currently used in our high-enrollment molecular biology and biochemistry lab course. They have been optimized to be high-throughput and easy to implement, while still providing valuable measures of these lab skills and being fun and engaging for the students.

The first lab practical exercise tests dilution math and pipetting skills, and the students perform an assigned dilution in a fixed amount of time under the supervision of the instructor or teaching assistant (TA). The exercise can be carried out while the class works on the main lab activity for that day. The students come one at a time to a work station equipped with a full set of micropipettes, pipette tips, dye solution, diluent buffer, and a 96-well microtiter plate. They are instructed to perform a specific dilution of the dye solution in one well of the 96-well plate (e.g., a 1:75 dilution), and must complete this dilution in three minutes. The three-minute time requirement helps to ensure proficiency in these skills, and the TA rotates between three different dilutions to decrease the chance that the students will know the dilution before arriving at the lab practical station. The TA can rapidly score the lab practical once all the students have completed the exercise by reading the absorbance for each dilution well with a plate reader. The absorbance from each dilution must fall within a specified range (typically +/- 0.05 absorbance units) from the average absorbance obtained from five repeat standards of that dilution prepared by the TA. The student does not pass the lab practical if the absorbance falls outside of that range. The lab practical exercise is typically administered twice during the term to give students a chance to improve these skills. A practice station is set up in the lab classroom where the students self-administer the exercise by drawing cards with assigned dilutions and timing themselves. Many students do not pass the lab practical the first time, so the chance to practice before taking the practical again is an important element of teaching these skills. The diluent is 0.01 M sodium phosphate, pH 7, and the dye solution is 0.01% bromophenol blue in the phosphate buffer diluent. The microtiter plates are read at 595 nm. Other dyes can be substituted for bromophenol blue, and the microtiter plates can be washed and reused indefinitely. While not all teaching laboratories will have access to a plated reader, this exercise can be adapted for use with a standard spectrophotometer.

The second lab practical exercise tests use of the microcentrifuge and the ability to manipulate small pellets. We had noticed historically that students in our laboratory course frequently had trouble resuspending pelleted material without introducing an inordinate amount of bubbles, leading to a "foamed" pellet and making it difficult to complete the experiment. This exercise was developed to address this problem and better develop these pipetting skills in our students. The students work with a solution of bovine serum albumin (BSA) that has been precipitated with ammonium sulfate to produce a suspension that readily forms pellets upon centrifugation. These pellets easily go into solution upon suspension in water. The students pipet 50 µL of the BSA solution into a microfuge tube and centrifuge this for 5 minutes at full speed to produce a small pellet. They must remove all of the supernatant and then have their TA confirm that they have done this without disrupting the pellet. The students must then dissolve the pellet in 20 µL water without introducing any bubbles into the solution, and again have their TA confirm they have done this successfully. We use this exercise to provide students with the chance to practice these skills, and they are allowed to repeat it as many times as necessary. The exercise could also be implemented as a lab practical assess-

ment to count for part of the laboratory grade. The 5% BSA solution with ammonium sulfate is made by dissolving 10 grams BSA (Fisher #BP1605-100) in 200 ml water, and then slowly adding 112.2 grams ammonium sulfate with rapid stirring until dissolved. The solution should be stored at 4°C.

We have used both of these exercises in our high-enrollment lab course for several years now, and they are an important part of how we teach and assess basic laboratory skills. Mastery of these basic skills is essential for students to be competent at carrying out the experimental techniques used in molecular biology and biochemistry. The reagents and supplies necessary for carrying out these exercises are inexpensive, and the setup required is minimal. Designing lab practical exercises that will work within the constraints of a particular lab course does take some consideration and effort. However, the potential benefits in terms of lab skills acquired, student confidence, and assessment of lab course effectiveness justify this initial time expense. With some effort, it should possible to implement lab practical assessment that is both affordable and effective in a high-enrollment setting.

Literature Cited

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