Development of a Capstone Concept Assessment to measure integrated content retention in biology

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Introduction

The intent of this proposal is to begin developing a Capstone Molecular Biology Concept Assessment (Capstone MBCA) to evaluate how well graduating seniors in Molecular Cell and Developmental Biology (MCDB) can integrate and apply concepts from all their coursework. Such an assessment tool will have widespread impact in supporting the transformation of undergraduate education and providing a resource to evaluate meaningful student learning. Some of the expected uses of this tool are: 1. To measure the level of conceptual learning in graduating biology majors, 2. To measure conceptual learning gains between beginning and end of final year of coursework, 3. To measure the level of content retention after graduation, 4. To help determine which different models of pedagogy can help to promote long-term content retention and integrative abilities. The Capstone MBCA can be used not only at CU, but at any college or university department that teaches genetics, molecular biology, and cell biology, across the nation and internationally. It may also be valuable to science educators in other disciplines, as well as to science teachers at the secondary school level.

Project Proposal

Much research has shown that in-class active-learning activities, which engage students through discussion of conceptually challenging questions and collaborative work in small groups, improve student performance in a course (e.g. 1-3). However, there is little research regarding how much conceptual understanding students retain, either within a course as the instructor moves from one topic to the next, or after the course is over. Retention of learned concepts is critical for students’ progress through their major, as well as for an ultimate in-depth understanding of the discipline. Retention allows instructors to build on previously learned concepts (rather than having to review them in each new course), and ultimately allows students to apply their knowledge to new situations (a job in their discipline, or the next level of their studies). Better retention of fundamental concepts in biology will increase the overall scientific literacy of our students, whether as non-scientist citizens making decisions about health and environmental issues, or as scientists engaged in research and development in these areas.

The MCDB Science Education Initiative group has helped faculty use assessment tools in individual courses to measure what students learn using one of the biology assessment tools: the Biology Concept Inventory (http://bioliteracy.colorado.edu/), the Genetics Concept Assessment (4), or the Intro to Molecular and Cell Biology Assessment (5). These tools were all developed at C.U., have been used to measure student conceptual understanding of biology (6,7), and are now used by faculty at other institutions as well. In order to develop an assessment that integrates across the content of the major, I have asked the faculty who teach each of the three final capstone courses in MCDB to establish one set of overall common learning goals. Since the capstone courses are intended to integrate and apply the concepts taught earlier in the major, these goals can also be used to guide the development of the Capstone MBCA. The proposed assessment will be designed to
measure in-depth understanding, with questions targeted at the higher levels of Bloom’s taxonomy (application, analysis, synthesis, and evaluation) (8).

The following steps, based on the procedures used for developing other concept assessments in multiple disciplines (9-12) will be taken to develop and validate the Capstone MBCA:

**Step 1: Establish a set of learning goals that are common to all 3 capstone courses in the major, and which reflect the most important concepts students should be familiar with upon completion of the major.** Through meetings with the faculty who teach the capstone courses, we have established an initial set of learning goals and a set of open ended questions.

**Step 2: Collect free-response answers to open-ended questions through student interviews and create distracters and correct answers from student supplied responses.** One-on-one think-aloud student interviews will be used to collect student ideas on questions that address the established capstone learning goals. Data from student interviews and free-response answers will shared with the instructors above, as well as with at least two additional faculty who teach other upper-level courses. Feedback will be used to refine the questions and to generate multiple-choice correct and incorrect answers in simple language with minimal technical jargon. These pilot questions will be reviewed by at least three internal faculty and modified accordingly. We will then verify the validity of these answers by interviewing another group of students. In these interviews, students will select an answer to each question and then explain their thinking to the interviewer.

**Step 3: Administer pilot assessment and interview additional students.** Once a pilot assessment is ready, the assessment will be given to two groups of students (likely in fall ’10): students who have taken a capstone course and are graduating, and students who have taken all the courses except the capstone. Data on student performance as well as individual interviews will help to further refine questions on the assessment.

**Step 4: Solicit evaluations of the questions from external faculty.** The assessment will be evaluated by at least 10 faculty experts (Ph.D.’s who perform molecular biology research and teach undergraduate courses) from multiple institutions. They will rate each assessment question for scientific accuracy, clarity, and connection to the learning goal for which it was written. At least 80% of the experts must agree that these criteria are met; otherwise, the question will be revised, and re-validated through student interviews.

**Step 5: Repeat the student interview and external faculty evaluation process.** Finally, questions will be revised based on additional expert input and additional rounds of interviews with students.

**Timeline**

Spring ’10 (current): A list of learning goals for graduating MCDB seniors has been established in collaboration with the instructors of the thee capstone courses for the major (Jenny Knight, Bill Wood, Kevin Jones and Corrie Detweiler) and the MCDB Science Teaching Fellows. The first round of student interviews is currently being conducted (by Caleb Trujillo, research assistant) to establish concepts that MCDB students continue to struggle with even after completing all but the capstone courses in the major.
Summer ’10: Continue student interviews. Build multiple choice questions based on student interviews and feedback from faculty. Interview additional students on the pilot version of the multiple choice questions. Solicit additional expert review.

Fall ’10, Spring ‘11: administer the pilot Capstone MBCA to seniors. Analyze data. Revise assessment and interview additional students, solicit additional expert review, and re-administer assessment. This cycle will be continued until we are satisfied that we have a meaningful, valid and reliable assessment tool.

Evaluation

The process of building an assessment has evaluation built in at each step (interviews, analysis of pilot assessment questions, expert review; see above). The expert review is particularly important for such an assessment, since its ultimate usefulness depends on its value to instructors within MCDB, as well as its value to instructors in other departments. To this end, at least 3 faculty within MCDB will be asked to help evaluate the learning goals and open-ended questions for interviewing students, and at least 10 additional experts will be asked to review the pilot assessment once it is built.

References