Biology Department
Unit-Level Assessment Liaison Report
Spring 2019

Liaison Project Start Date: Spring 2018
Liaison Report prepared by Aigerim Bijelic

I. Department Buy-In and Outcome Definition

In the Spring 2018 semester, with the help of the Biology Assessment Committee, we designed a pilot assessment survey for Biology 121, Introductory Biology for science majors. The survey assesses student learning of twenty core concepts taught in Biology 121. All twenty core concepts are closely aligned with the student learning outcomes focusing on the following fundamental topics: basic principles of atomic structure, chemical bonds, organic macromolecules, cellular organization, major metabolic pathways, enzyme function, flow of genetic information, and mutations and their role in cancer.

The following student learning outcomes were addressed in the assessment survey that consisted of 20 multiple choice questions:

· 1) Recognize dependent, independent and controlled variables in an experiment
· 2) Summarize the basics of atomic structure
· 3) Recognize and predict molecules or parts of molecules that are hydrophobic or hydrophilic
· 4) Distinguish between three main types of chemical bonds: covalent, ionic and hydrogen
· 5) Compare and contrast 4 classes of biological molecules (carbohydrates, lipids, proteins, nucleic acids)
· 6) Compare the structural hallmarks of bacterial (prokaryotic) cells and eukaryotic cells

· 7) Differentiate among different types of transport across plasma membrane
· 8) Explain the principles of enzyme function
· 9) Distinguish and compare the processes by which organisms fuel growth and cellular activities (cellular respiration and photosynthesis)
· 10) Explain what is DNA replication and when it happens
· 11) Discuss what happens when cell cycle control mechanism is damaged
· 12) Explain how mistakes in cell division can lead to cancer and chromosomal abnormalities
· 13) Diagram the flow of genetic information in cell
· 14) Compare and contrast the outcomes of cell division via mitosis and meiosis
· 15) Recognize that DNA sequences have a meaning
· 16) Explain what mutations are and how they affect genetic code

II. Assessment Research and Design

The pilot survey consists of 20 multiple-choice questions. Most of the questions are considered to be at level 1 (understanding) and level 2 (comprehension) based on Bloom's taxonomy. Few questions of the survey are at level 3 (application) of Bloom's taxonomy. Some multiple-choice questions were adapted from the research literature (1-3) and publishers' test banks, while some questions were designed from scratch. All of the questions in the pilot assessment survey are closely aligned with the above-mentioned student learning outcomes of Biology 121.

III. Pilot Assessment Tools and Processes

The pilot survey was administered in 5 sections of Biology 121 at the end of Spring 2018 semester. A total of 92 students took the survey.

Some of the most common misconceptions included the following:

· Water molecules are attracted to each other through polar covalent bond (SLO #4)

· In the process of cellular respiration, glucose is digested into smaller molecules, leading to the breakdown of ATP (SLO #9)

· Mutations that arise in any body cell (somatic mutations) and lead to cancer in an individual can be inherited by an individual's children (SLO #16)

· Genetic information provides instructions to rearrange genes into traits (SLO #13)

IV. Administer Specific Assessment

Prior to the start of the Fall 2018 semester, the Biology Assessment Committee met to look at the preliminary results of the pilot survey from the Spring 2018 semester. During the meeting, we reviewed the questions that were most frequently answered incorrectly to see if it was due to a lack of understanding of the concept or just a problem with the wording of the particular question. At that meeting, there was a suggestion made by several members of BioAC to rephrase wording of some questions to make them more clear and to remove few questions because they were too simple. As a result of this, the survey was revised and a new version was administered as a pre- and post-test assessment in Fall 2018 semester.

During the first week of Fall 2018 classes, the pre-test assessment was administered in all 10 sections (9 face-to-face and 1 hybrid) of Biology 121. A total of 260 students participated in the pre-test assessment.

The same assessment was given as a post-test in 9 sections of BIO 121 during weeks 15 and 16 of the Fall 2018 semester. A total of 155 students participated in the post-test assessment. This is also the number of students who took both pre- and post-test.

V. Data Analysis

Results of both pre- and post-test assessment were analyzed by the Assessment Committee's Research Analyst, Professor Fernando Miranda-Mendoza. Out of the 155 students that took the

post-test assessment, only 134 had a record based on student ID of taking the pre-test assessment. Results presented here are based on these 134 students.

A Welch's two-sample t-test was performed to test differences in (percentage) mean performance between the pre-test and post-test assessment. A statistically significant difference (at the standard 0.05 level) was detected (p-value = 4.27×10^{-5}). Based on this result, we can claim that the average student performance in the post-test (Mean=61.58%) is statistically significantly higher than the average student performance in the pre-test (Mean=50.56%).

In addition, effect size, which indicates the importance of difference between the pretest and posttest, was measured. This is also called "learning gain" in this analysis. The effect size in this case equals 0.77. Several measures of effect size exist and no consensus as to which one is the "best" exists. The effect size calculated above is called *Cohen's d* and appears to be widely used in educational circles (Cohen, p. 17). Standard interpretations of effect size suggest that the effect size of 0.77 is somewhat large and thus the learning gain is substantial.

VI. Supporting Evidence-Based Change (Use of Findings)

During the registration week of Spring 2019 semester, members of the Biology Assessment Committee met several times to discuss the results of the pre-test assessment data. In particular, we were interested to know what were the most common student misconceptions. As a result of our discussions, we came up with the following preliminary recommendations that were shared with all faculty of the Biology department:

1) Misconceptions about the role of nutrient molecules, process of cellular respiration, and ATP in energy metabolism (SLO #9)

Possible ways to address the misconception:

· Start introducing the basics of energy metabolism (i.e what is ATP, role of cellular respiration) early on in the semester, for example when discussing Biological Macromolecules.

2) Misconception that plants only carry out photosynthesis and not cellular respiration. Possible ways to address the misconception (SLO #9)

· Introduce cellular respiration and photosynthesis early on in the semester. and come back to these concepts throughout the semester. For example, start introducing the roles of cellular respiration and photosynthesis when discussing bio macromolecules (i.e when comparing plant and animal storage carbohydrates). When discussing cellular structures of plant cells, an emphasis can be put on the presence of mitochondria in these cells.

3) Misconception about the differences between somatic and germline mutations and their effects on cells/organisms (SLO#9 and 16)

Possible ways to address the misconception:

· Introduce cell classification (somatic versus germline cells) when discussing cell structure and organization.

· Start discussing mutations in somatic cells vs. germline cells when addressing DNA replication and mitosis.

· Continue discussing the differences between somatic and germline mutations and whether they are inheritable or not when addressing meiosis.

4) Misconception about the function of DNA as a source of genetic information, the flow of genetic information and its use in the cell (SLO #13).

Possible ways to address the misconception:

· Introduce the function of DNA and the flow of genetic information early on in the semester, i.e when discussing bio macromolecules.

· Continue addressing these concepts when covering cell structure, DNA replication, protein synthesis.

Success Factors

Based on the analysis of the Fall 2018 post-test assessment results, the average student performance in the post-test (Mean=61.58%) was statistically significantly higher than the average student performance in the pre-test (Mean=50.56%). In addition, comparing pre- and post-test results showed that the learning gain was substantial. Our department will continue to make adjustments in order to improve the rate of student learning.

Since formation of the Biology Assessment Committee in Spring 2018, members of the committee held several meetings during Fall 2018 and Spring 2019 registration weeks to discuss the ongoing unit-level assessment process in Biology 121 and share our experiences with assessment in other courses. In addition to this, we meet a few times throughout the semester to continue our discussions. There has been an increasing level of interest in assessment among the faculty in the department, which has led to many engaging and meaningful conversations about what we want our students to learn about biology. In addition, during registration week of Spring 19 semester, one of our departmental assessment meetings was attended by several officers of HWC Assessment committee and unit-level assessment liaisons from other departments. This provided a good opportunity for BioAC members to ask questions from the HWC Assessment members and to share our challenges with assessment in biology.

Another success story in our department assessment practice is a participation of unprecedented number of students (a total of 260) in the pre-test assessment at the start of Fall 2018 semester. All instructors of BIO 121 (both full and part-time) had volunteered their BIO 121 sections, which shows an increased awareness and willingness of our faculty to participate in assessment process. This serves as a foundation for our department to continue building our assessment practice and expertise.

Recommendations

As mentioned in the section VI. Supporting Evidence-based Change, a number of recommendations based on the Fall 2018 pre-test assessment were formulated by the members of the Biology Assessment Committee and shared with all faculty in our department.

Another recommendation is that we administer future assessment tools as an online assessment survey using Google Doc with the goal to not take time away from regular instructional time and to make the process of scoring and analyzing the assessment results easier and more efficient.

In addition, it is recommended that if we do continue to use Scantrons instead of Google forms, we use different format scantrons that would allow students to bubble in their student IDs, which would make transferring student answers to Excel files faster and more efficient.

Appendices

References:

1. Shi J. *et al*." A diagnostic assessment for introductory molecular and cell biology." *CBE Life Sci Educ*, vol. 9, 2010, pp. 453-61.
2. Wilson C. *et al*. "Assessing Students' Ability to Trace Matter in Dynamic Systems in Cell Biology". *CBE Life Sci Educ*, vol. 5, 2006, pp. 323-331.
3. Queloz A. et al. "Diagnostic of students' misconceptions using the Biological Concepts Instrument (BCI): A method for conducting an educational needs assessment." *PLOS One*, vol. 12, no. 5, 2017, e017690.
4. Cohen, J. *Statistical power analysis for the behavioral sciences*. Routledge, 2013.