

Biology Department 2017 Assessment Report

Prepared by Nicola Barber

Overview

For the Biology Department 2017 Assessment we administered a validated assessment instrument called the Molecular Biology Capstone Assessment (Couch, Wood & Knight, 2015) to students enrolled in upper level biology courses. This assessment directly aligns to our department's learning outcomes. We found that our students performed comparably on the assessment to students in the published report. Identified areas of student difficulty with molecular biology concepts will be considered in the context of the curriculum. We noticed that under-represented minorities scored lower than the overall average on the assessment indicating a need for us to better support this student population. Our next steps are to: 1) identify particular barriers to success experienced by underserved student groups in our major and 2) implement inclusive strategies to improve overall student success in our courses and major. Ongoing departmental efforts on this front include a supplement instruction program for General Biology I (Learning Biology) in its second year, an effort to better document the learning and teaching in the General Biology sequence led by the curriculum reform committee, and efforts to connect with local partners including the Northwest Bioscience Consortium who are also taking on similar work. Future assessment will employ a forthcoming validated assessment instrument that will cover the full range of departmental learning outcomes and be administered before and after students complete the General Biology sequence.

Introduction

Nationally the conversation around biology education has been shaped by the Vision and Change in Undergraduate Biology (V&C) (AAAS, 2011) initiative backed by the NIH, NSF, USDA, AAAS and HHMI. V&C outlines core concepts and competencies very similar to our current biology department learning outcomes. This year our department formally adopted updated biology learning outcomes that are directly aligned with V&C. By adopting the V&C learning outcomes we can make use of validated assessment instruments developed and tested by biology education researchers. The instruments are part of a NSF-funded BioMAPS (Biology-Measuring Achievement and Progression in Science) multi-institutional collaborative to develop V&C core concepts aligned assessments in different biology content areas (molecular biology, general biology, ecology and evolution, and physiology). The use of validated and broadly used assessment items will allow us to more rigorously evaluate our program, compare our program to other programs that are aligned to V&C, and meaningfully measure student outcomes in response to changes in the curriculum (e.g., quantitative literacy initiative, Learning Biology). These instruments are designed to be sensitive to a range of student achievement levels, and we expect these to be challenging assessments for students (to reduce the potential for ceiling effect in high achieving students). Nicola Barber and Elly Vandegrift spearheaded the department assessment efforts, based on our involvement with national V&C discussions, northwest biology faculty associations, and biology education research experience.

For the 2017 Assessment project we administered the Molecular Biology Capstone Assessment (MBCA) (Couch, Wood, & Knight, 2015) as an online qualtrics survey assessment to students enrolled in 300 and 400-level biology courses in Spring 2017. The Molecular Biology Capstone Assessment is a validated concept inventory, affiliated with the BioMAPS project. This assessment is designed to be administered near the end of a student's undergraduate career and online administration has been shown to be as effective as in class (Couch & Knight, 2015). It was developed, refined and validated by biology faculty members and has shown to be aligned to the Core Concepts outlined in Vision & Change (AAAS, 2011) upon which our departmental learning outcomes are based (Table 1, Couch, Wood, & Knight, 2015). Results of the survey were compiled by Nicola Barber. Based on concerns about achievement gaps in our general biology sequence among first generation college attendees, students with demonstrated financial need (Pell eligible), and under-represented minorities we engaged Claire Matese from Institutional Research to run further data analysis on how students from these demographics performed on the assessment. We discussed the results at our annual biology faculty retreat and are using the results to guide conversations about our approach to teaching and our curriculum.

Table 1. Overview of the MBCA development process

1. Identify a set of fundamental concepts and learning objectives through individual faculty interviews, faculty roundtable discussions, and literature review.
2. Conduct open-ended interviews to probe student understanding of these concepts.
3. Draft a series of multiple-T/F questions incorporating student ideas as statements.
4. Conduct think-aloud student interviews to ensure question clarity and response validity.^a
5. Solicit feedback from biology faculty members at multiple institutions for approval of question content.^a
6. Administer the assessment to upper-division students at multiple institutions.
7. Perform analyses to determine overall student performance, question statistics, and instrument reliability.

^aSteps 4 and 5 occur concurrently and are accompanied by iterative question revision.

Source: Couch, Wood and Knight, 2015.

Data collection and analysis: The MCBA was administered to 274 students who were currently enrolled in 300 and/or 400 level biology courses in spring quarter 2017. Some students received a small amount of extra credit for survey completion as determined by the instructor. The MCBA takes approximately 30 minutes to complete. To account for students who did not make significant effort in the assessment, we removed 46 submissions in which the assessment was completed in less than 15 minutes. This left us with 228 responses. The MCBA is designed as a capstone assessment targeting upper level students. 137 of the 236 students identified as biology majors (131) or marine biology majors (6). An additional 32 identified as biology minors. 51 of these biology/marine biology major students identified as graduating seniors (spring or summer 2017). 133 students participated in the spring graduation ceremony indicating we reached 38% of our graduating students. Data analyses were performed with the larger sample of 236 students who were enrolled in upper level biology classes, as well as various student subgroups including: the 137 students who identified as biology or marine biology majors and the 51 students who identified as graduating senior (spring/summer 2017) biology or marine biology majors. The MCBA has 18 question stems with 4 True/False (T/F) statements each for a total of 72 statements. Each T/F statement response was scored as 1 = correct, 0 = incorrect. Non-responses were counted as incorrect. Fractional scores (% correct) were calculated as a sum of correct responses divided by the total number of statements and presented as a percentage (%).

Results: The overall mean for all students who completed the MCBA at UO in Spring 2017 (n=228) was 64.79 ± 9.8 % SD. When Couch et al., 2015 tested the MCBA with 504 students from upper division biology courses across 7 institutions the overall mean was 67.2 ± 11.5 % SD. We broke down student overall percent correct by various student groups including biology majors, graduating majors, non-graduating majors, non-biology majors, non-biology/biochemistry majors, under-represented minorities, Pell eligible, and first generation college attendees (Table 2 and Figure 3). We also broke down UO student performance by question and made question by question comparisons to the published student data in Couch, Wood & Knight, 2015 (Figure 2 and 3). The breakdown of concepts tested on each item are in Appendix I and this comparative analysis revealed that our students are having particular difficulty with details of the connection between DNA and traits (items 5, 9, 18), how DNA is partitioned into sex cells (item 11), and how molecules move through and between cells (items 12, 16). UO students notably outperformed students in the published dataset on item 10 which targeted how cells communicate through signaling molecules. When we looked at the overall percent correct we observed small differences between various students groups (Table 2, Figure 3). The highest overall means were 68.59 ± 10.3 % SD for graduating biology majors, and 67.8 ± 9.2 % SD for biochemistry majors. The lowest overall means were 61.51 ± 8.91 % SD for non-biology or biochemistry majors, and 61.74 ± 10.63 % SD under-represented minorities. We further broke down performance on individual assessment questions for under-represented minorities and found lower mean scores across most questions (Figure 4).

Discussion: The higher mean score for graduating majors suggests that students continue to improve their understanding of molecular biology through their upper-level biology coursework. The lower mean score of under-represented minorities indicates that this student population is still underserved at the upper level. We see higher non-completion (DFW) rates across introductory science majors courses for students who are Pell eligible, first generation college attendees, and under-represented minorities. These new data from the MCBA suggest that while Pell eligible and first generation college attendees no longer have achievement gaps in the upper levels of coursework, we still need to better support our under-represented minorities at this level.

The data in this report, along with introductory course non-completion rates and biology graduation and retention data, were shared at the biology department's annual faculty retreat and faculty were asked to circulate to various stations with these data on display to hold conversations and leave written comments about the data. The prompts for the comments were "what is notable or surprising in the data" and "hypotheses for patterns in the data". Groups of faculty then worked to summarize these comments for particular data sets and presented them to the whole group. Finally faculty left individual reflections on index cards in response to the prompts "Where could we use more data to inform improving our undergraduate education?" and "What should our annual assessments target in the next few years?." These materials were gathered and analyzed.

Faculty responses to the assessment data did not identify any particular concerns about content areas, with the exception of student understanding of meiosis. Generally faculty felt that the data revealed our students performed slightly lower than

the published dataset in Couch, Wood & Knight, 2015 but likely not significantly so. There was surprise that the difference between the performance of majors and non-majors on the assessment was not larger. It was also noted as a positive, that our graduating majors scored higher on the assessment than other groups. Faculty noticed that unlike Pell eligible and first generation students, our under-represented minority students had lower scores than average across the assessment. There were suggestions that we compare our data to nationally available data but we are still at the early stages of advancing the conversation from recognizing achievement gaps to identifying barriers to student success and implementing efforts to address the barriers.

At the faculty retreat we also shared biology student retention and graduation data along with course non-completion rates in the introductory science and math courses. Faculty conversation on these datasets surrounded why we are not retaining students in biology and why students are moving into the human physiology major. It was suggested that loss of students could be do the math failure and that under-represented minorities may not feel a sense of belonging in biology. Of the four courses in our general biology sequence, it was noted that BI-213 General Biology: Populations has the lowest failure rates. Many were concerned about the high non-completion rates. Faculty were surprised to learn how much our transfer students are struggling to complete introductory courses.

General feedback from faculty discussion and index card reflections indicated a desire to do more statistical analyses to look for significant differences. One caveat is that our power to detect statistical significance is limited by the size of our student populations, especially for minorities. It was noted that an over-reliance on statistics could take away from the critical perspective that this data represents the experiences of individual students in our courses and major. Furthermore, differences in student success or performance can be statistically insignificant due to small sample sizes but still real and important, especially when our data reflects the trends seen in national data about under-served student populations. In addition to performing further statistical analyses, we can compare our data to national data, maximize our sample sizes and make use of analyses of whole student populations.

Other efforts to improve student experience: The biology department has launched a supplement instruction program (Learning Biology) that is paired with Bi211 (General Biology I: Cells) to support students who do not achieve passing score on the first midterm exam. Additionally a Biology curriculum reform committee is reviewing the majors introductory sequence during the 2017-18 academic year and will propose curricular changes based on the student success data available. Across the state the Northwest Bioscience Consortium will be meeting in early 2018 to develop state-wide learning outcomes for introductory majors biology and improve articulation between 2- and 4-year institutions across the state. Faculty from the University of Oregon will participate in these conversations this year.

Future assessment: We would like to next measure student learning in the Bi 211-214 General Biology sequence using a BioMAPS instrument that has been validated for introductory biology majors courses and covers material across all our learning outcomes. This instrument is awaiting publication and we have requested permission to

launch it when it becomes available. Faculty feedback generally agreed that it would be particularly useful to administer this assessment (and others) with a pre-post test design to measure learning gains across our introductory sequence or the major. There was a desire to compare our data to nationally available data sets. It was also suggested that we speak with students directly about what is and is not working for them. There was general enthusiasm among the faculty for collecting more data on student success and learning, but we did not have the time at the faculty retreat to move the conversation beyond the current data towards existing barriers and new ideas for improving the student experience beyond existing efforts. These will be ongoing conversations in future faculty meetings as we build a departmental model of data-driven and research-based support for undergraduate education.

Table 2. Molecular Biology Capstone Assessment outcomes for students enrolled in upper-level biology classes and various student sub-groups.

	N	mean overall score	standard deviation
All	228	64.79	9.81
Majors	131	66.22	10.12
Graduating majors	47	68.59	10.33
Non-graduating majors	69	64.39	9.76
Non-majors	97	62.86	9.08
Non-majors bio/biochem	76	61.51	8.91
Biochem majors	27	67.8	9.2
Under-represented minorities	31	61.74	10.63
Pell eligible students	64	65.47	9.62
First Generation college attendees	55	65.43	9.17

Overall - Student enrolled in upper level (300 and 400 level) biology courses in Spring 2017

Majors - Student enrolled in upper level biology courses who are biology/marine biology majors

Graduating majors - Student enrolled in upper level biology courses who are biology/marine biology majors graduating spring/summer 2017

Non-graduating majors - Student enrolled in upper level biology courses who are biology/marine biology majors graduating in 2018 or beyond

Non-majors - Student enrolled in upper level biology courses who ARE NOT biology/marine biology majors

Non-majors bio/biochem - Student enrolled in upper level biology courses who ARE NOT biology/marine biology/biochemistry majors

Biochem majors - Student enrolled in upper level biology courses who are biochemistry/chemistry majors

Underrepresented Minorities - Students enrolled in upper level biology courses who self-reported to the University that they identify as Black/African American, Native American/Alaska Native, Native Hawaiian/Pacific Islander, Hispanic/Latino, and Two or More Races if at least one race/ethnicity is URM.

Pell Eligible - Students enrolled in upper level biology courses who qualified for financial aid in the form of a federal Pell grant

First Generation college attendees - Students enrolled in upper level biology courses who self-reported data on their admissions application that they were the first in their family to attend college.

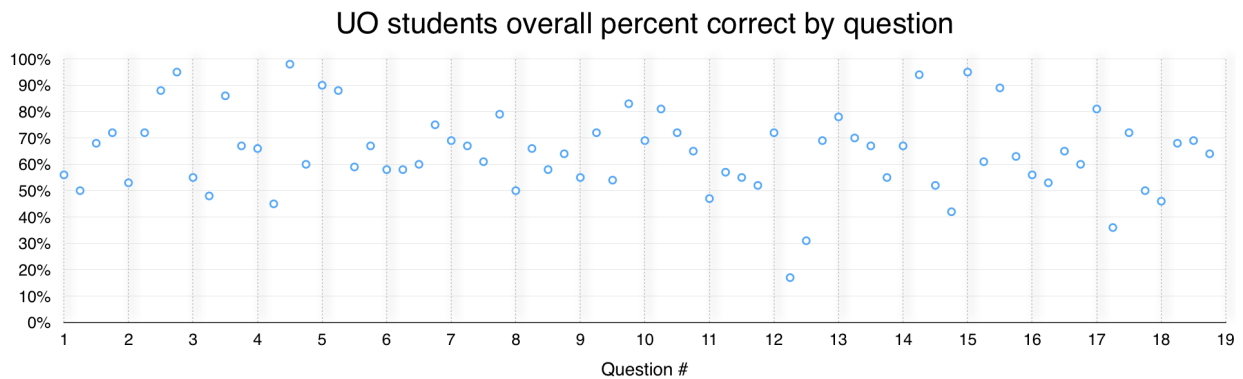


Fig. 1 Molecular Biology Capstone Assessment overall percent correct by question for students enrolled in upper-level biology classes at UO.

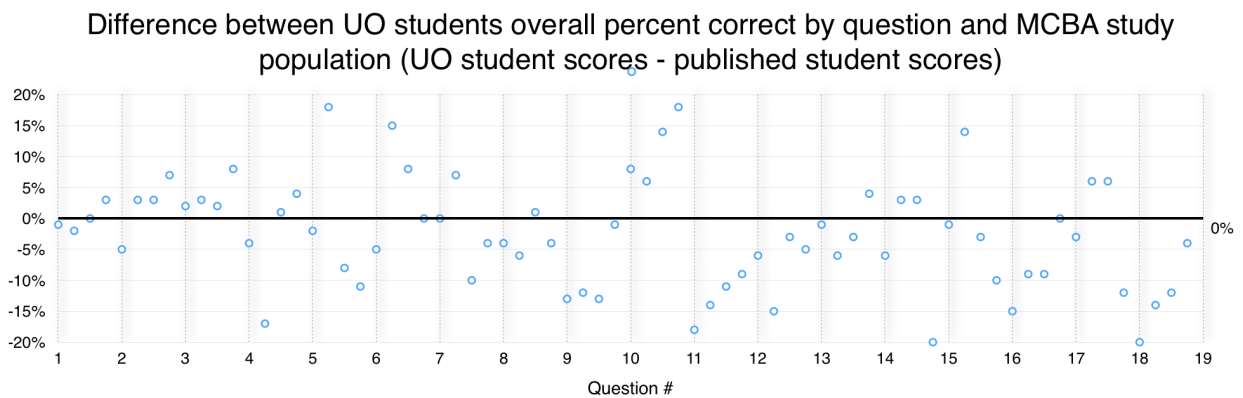
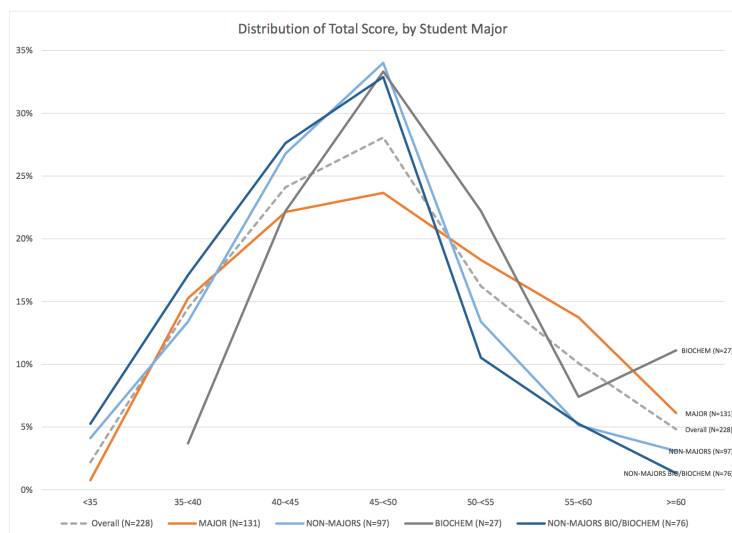
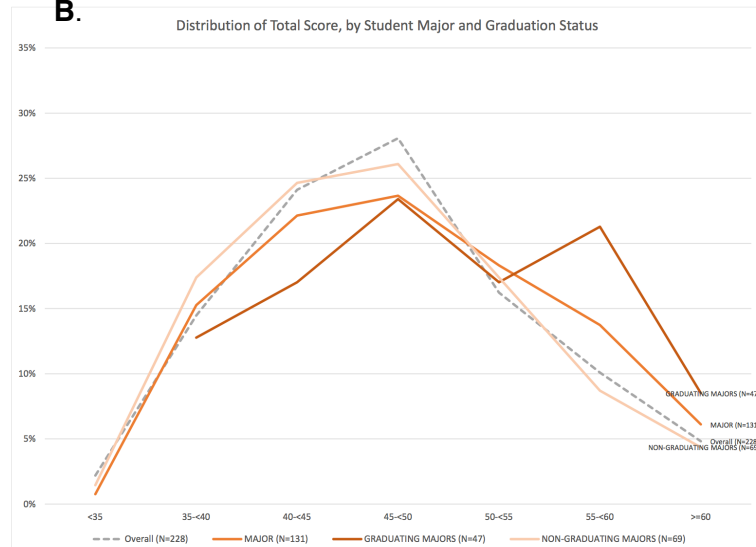


Fig. 2 Molecular Biology Capstone Assessment outcomes for students enrolled in upper-level biology classes at UO compared to published results of similar population

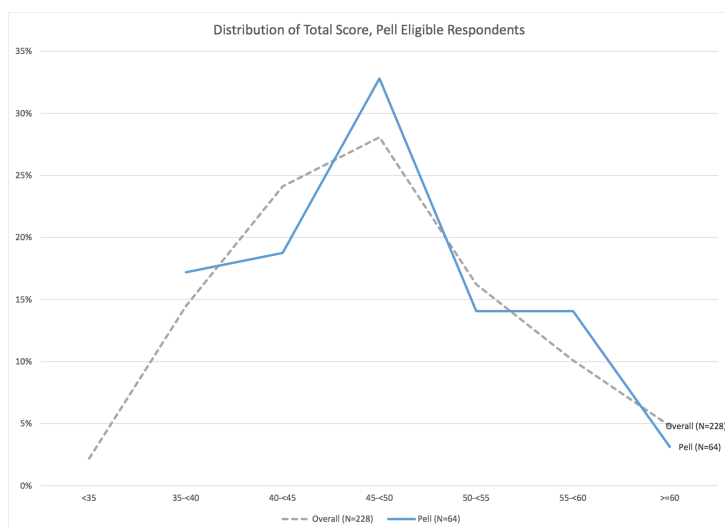
A.



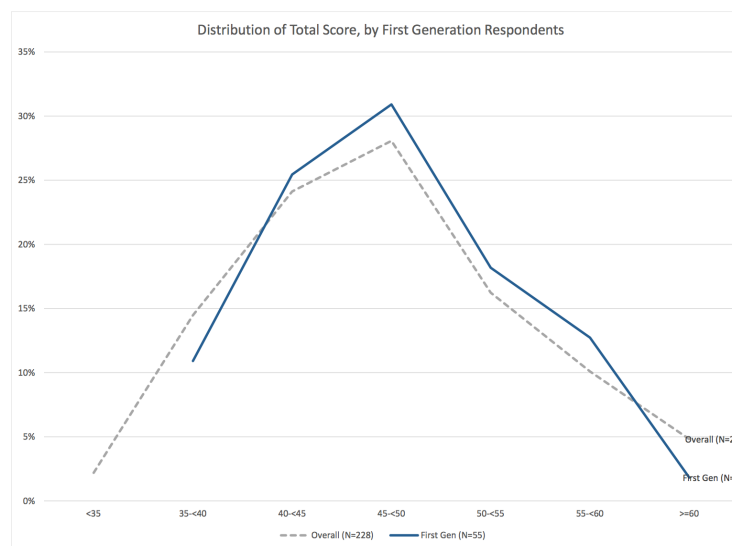
B.



C.



D.



E.

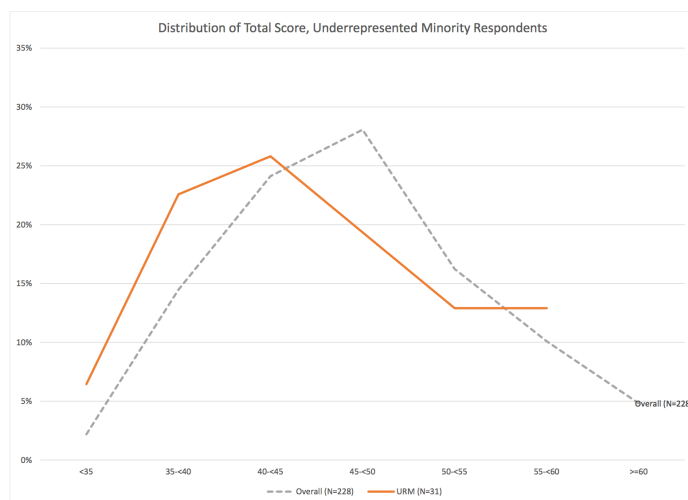


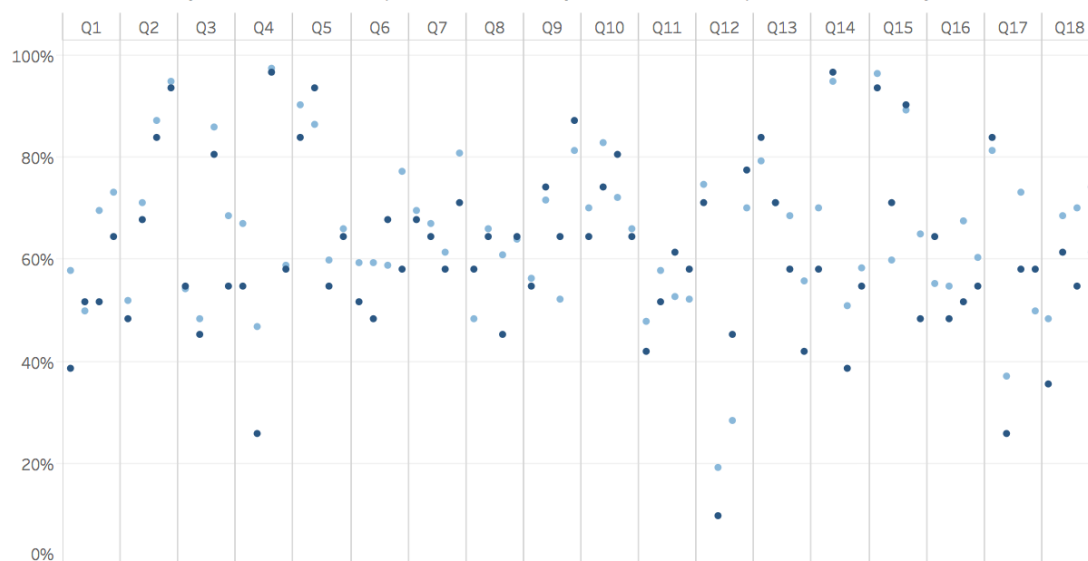
Figure 3. Distributions of Molecular Biology Capstone Assessment fractional scores (correct score out of 72 total) for students enrolled in upper-level biology classes and various student sub-groups.

A.

Molecular Biology Capstone Inventory Outcomes Underrepresented Minority

■ URM
■ Not URM

Percent Correct by Question, Underrepresented Minority and non-Underrepresented Minority



B.

Difference from Overall, Underrepresented Minority and non-Underrepresented Minority

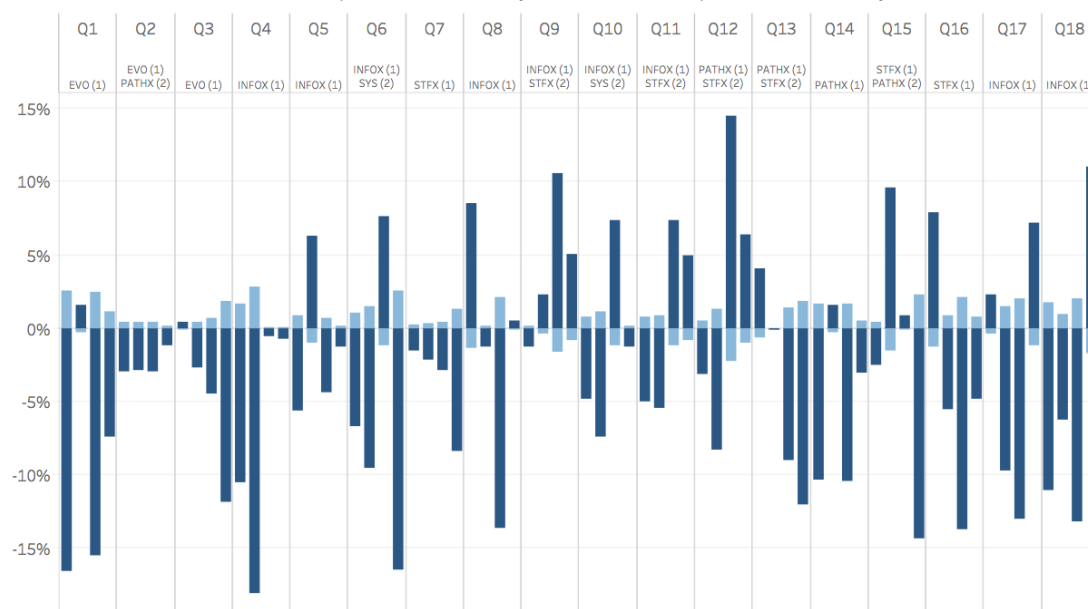


Figure 4. Molecular Biology Capstone Assessment item by item percent correct and difference from overall for under-represented minorities enrolled in upper-level biology classes.

References

- American Association for the Advancement of Science (AAAS). (2011). Vision and change in undergraduate biology education: A call to action, final report. Washington DC. <http://visionandchange.org/files/2013/11/aaas-VISchange-web1113.pdf>
- BioMAPS https://www.nsf.gov/awardsearch/showAward?AWD_ID=1322556
- Brownell, S. E., Freeman, S., Wenderoth, M. P., & Crowe, A. J. (2014). BioCore Guide: a tool for interpreting the core concepts of Vision and Change for biology majors. *CBE-Life Sciences Education*, 13(2), 200-211. <http://www.lifescied.org/content/13/2/200.full>
- Couch, B. A., & Knight, J. K. (2015). A Comparison of Two Low-Stakes Methods for Administering a Program-Level Biology Concept Assessment. *Journal of microbiology & biology education*, 16(2), 178. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4690558/>
- Couch, B. A., Wood, W. B., & Knight, J. K. (2015). The Molecular Biology Capstone Assessment: a concept assessment for upper-division molecular biology students. *CBE-Life Sciences Education*, 14(1), ar10. <http://www.lifescied.org/content/14/1/ar10.full.pdf+html>

Appendix I

Molecular Biology concepts tested by Molecular Biology Capstone Assessment by question

1. Genetic mutations arise randomly within a population.
2. The differential reproductive success of individual organisms within a genetically heterogeneous population leads to changes in the genetic composition of a population over time.
3. Diversity arises from evolutionary processes that cause populations to become reproductively isolated and genetically distinct.
4. Gene expression is subject to multiple levels of regulatory control.
5. One gene can direct the synthesis of multiple different protein products.
6. A cell's history affects its developmental fate and response to its environment.
7. Bacteria, archaea, and eukaryotes exhibit distinct differences in cell structure and function.
8. The effect of a mutation depends upon the nature of the mutation (base substitution, insertion, deletion, or DNA rearrangement) and its location within a gene.
9. A mutation that alters the translated portion of a transcript can affect the resulting protein sequence.
10. The output of a signaling pathway depends on the activities of upstream components.
11. Chromosome partitioning during meiosis and mitosis affects the genetic identities of the resulting daughter cells.
12. Individual molecules can move through a solution in a nondirected manner as a result of thermal motion and random diffusion.
13. Closed biochemical systems proceed toward states of lower free energy.
14. The rate at which a biochemical reaction approaches equilibrium is governed by the activation energy for that reaction.
15. Intermolecular interactions are governed by binding affinity and molecular concentrations.
16. Membrane proteins and membrane-enclosed elements maintain fixed topologies as they traffic through different cellular compartments.
17. Genomic markers can be used to identify the molecular bases of phenotypic variation within a population.
18. Genetic traits can be modulated by genetic, epigenetic, and stochastic mechanisms.