ANNUAL PROGRAM REPORT

College	College of Science
Department	Biological Sciences
Program	B.A., B.S. and M.S. in Biological Sciences
Reporting for Academic Year	2020-2021
Last 5-Year Review	2018-2019
Next 5-Year Review	2022-2023
Department Chair	Brian A. Perry
Authors of Review	Brian A. Perry, Ana Almeida, Maria Gallegos
Date Submitted	October 1, 2021

II-A. SUMMARY OF ASSESSMENT – UNDERGRADUATE PROGRAMS

A. Program Learning Outcomes (PLO)

Students graduating with a B.S. or B.A. in Biological Sciences from Cal State East Bay will be able to:

1. *Explain core biological concepts, including evolutionary processes, structure-function relationships across all levels of biological organization, homeostasis, information flow, matter and energy transformations, and the interactions and interconnectedness of living systems (ILO 6);*
2. *apply quantitative reasoning to explain biological phenomena and to address biological problems (ILO 1);*
3. *clearly communicate biological information in a variety of formats (written, oral, visual) using a style appropriate for the intended audience (ILO 1,2,6);*
4. *apply methods of scientific inquiry by formulating testable hypotheses, collecting and analyzing data, and reporting conclusions (ILO 1,6);*
5. *gather, interpret, and evaluate published scientific information (ILO 1,6).*

B. Program Learning Outcome(s) Assessed

B.S./B.A. Programs: According to our Long-term Assessment Plan, Year 3 Assessment focused on PLO1. In order to assess this outcome, the department used the Cornell University Biology Measuring Achievement and Progression in Science (Bio-MAPS) student survey in BIOL 320 (Evolutionary Biology) during Fall 2020.

C. Summary of Assessment Process

Instrument: For PLO1 assessment, Dr. Ana Almeida had BIOL 320 students complete two Bio-MAPS surveys: the (i) General Biology (GenBio-MAPS)[1]; (ii) Ecology and Evolution (EcoEvo-MAPS)[2] surveys. Students were able to complete both surveys online and were offered extra-credit for survey completion. BIOL 320 (Evolutionary Biology) is the last upper-division course all biology majors take prior to focusing on their specific concentration courses.

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[1] Couch et al. GenBio-MAPS: A Programmatic Assessment to measure Student Understanding of *Vision and Change* Core Concepts across General Biology Programs. CBE Life Sci Educ March 1, 2019 18:ar1. DOI:10.1187/cbe.18-07-0117.

[2] Summers et al. EcoEvo-MAPS: An Ecology and Evolution Assessment for Introductory through Advanced Undergraduates. CBE Life Sci Educ June 1, 2018 17:ar18. DOI:10.1187/cbe.17-02-0037.

Sampling procedure: All students were given equal opportunity to anonymously complete the two surveys. Sixty-five (65) students were enrolled in BIOL 320 during Fall 2020 during the time the survey was applied, and we received 35 (53%) valid responses for the GenBio-MAPS survey and 27 (41%) valid responses for the EcoEvo-MAPS survey.

Data Collection and Analysis: All valid responses for each of the surveys were used for downstream analysis. Both surveys assessed student mastery of *Vision and Change*[3] core concepts (i.e., Evolution, Information Flow, Structure and Function, Transformations of Energy and Matter, and Systems Thinking). In addition, the GenBio-MAPS survey assessed student understanding of three main areas of Biology: Cellular and Molecular Biology, Ecology and Evolution, and Physiology. In turn, the EcoEvo-MAPS survey included a detailed analysis of Ecology and Evolution Conceptual Themes (i.e., Heritable Variation, Modes of Change, Phylogeny and Evolutionary History, Biological Diversity, Populations, Energy and Matter, Interactions with Ecosystems, Human Impact), as well as the four dimensions of ecological knowledge (i.e., Dimension 1: Core Ecology Concepts; Dimension 2: Ecology Practices; Dimension 3: Human-Environment Interactions; Dimension 4: Cross-cutting Themes). Quantitative analysis was performed using a distribution of student responses around the median, 1st and 3rd quartiles using box-and-whiskers plots.

D. Summary of Assessment Results

Main Findings: The GenBio-MAPS asked students to evaluate a total of 175 statements across three main areas of Biology (Cellular and Molecular Biology, Ecology and Evolution, and Physiology), focusing specifically on the *Vision and Change* core concepts. On average, students correctly assessed 56% of the statements, and student performance ranged from 86% to 29% of correct answers with a 2% standard error. In terms of the 5 main core concept areas of *Vision and Change*, the median of correct answers ranged from 62% on *Structure and Function* to 46% on *Information Flow* (Figure D1). For all categories, most student performances were lower than mastery level (equal or greater than 70% of correct answers). *Systems Thinking* had the largest number of students at or above mastery (12 students), while *Information Flow* as well as *Transformations of Energy and Matter* had the smallest number of proficient students.

In terms of the three main areas of Biology (Cellular and Molecular Biology, Physiology, and Ecology and Evolution), median values of student scores ranged from 59% of correct answers on *Ecology and Evolution* to 54% in *Cellular and Molecular Biology*, suggesting an equivalent distribution of student performance across the three areas of Biology. Despite this even distribution, student performance was mostly below mastery with only 6 students scoring 70% or greater for each of the main areas analyzed (**Figure D2**).

[3] C. Brewer & D. Smith (Eds.) 2011. Vision and Change in Undergraduate Biology Education: A Call to Action. ISBN#: 978-0-87168-741-8.

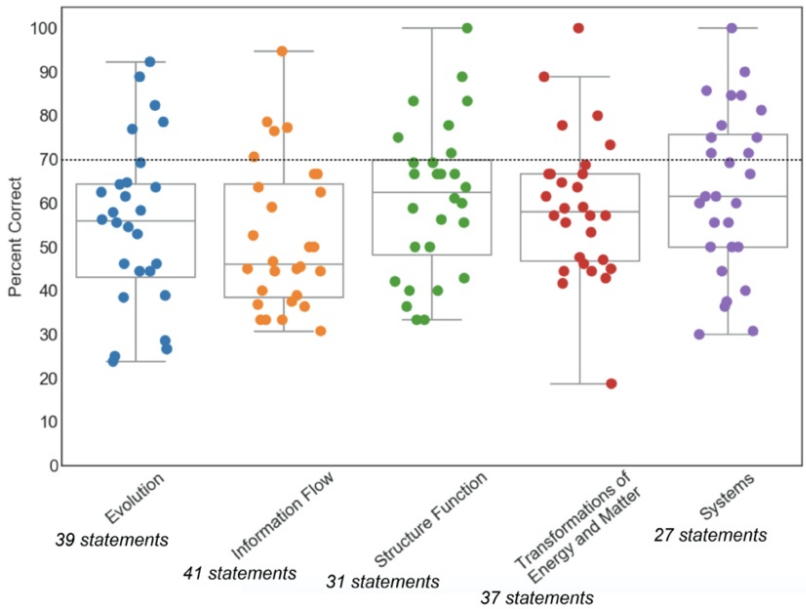


Figure D1 – Median, 1st and 3rd quartiles of percent correct answers for each of the core concept areas of *Vision and Change* in the GenBio-MAPS survey. The number of questions in each of the core area is presented below its respective label. The dashed line denotes a score of 70% correct answers, and scores at or above the dashed line indicates mastery. Colored dots represent the performance of each student in each of the five *Vision and Change* core concept areas.

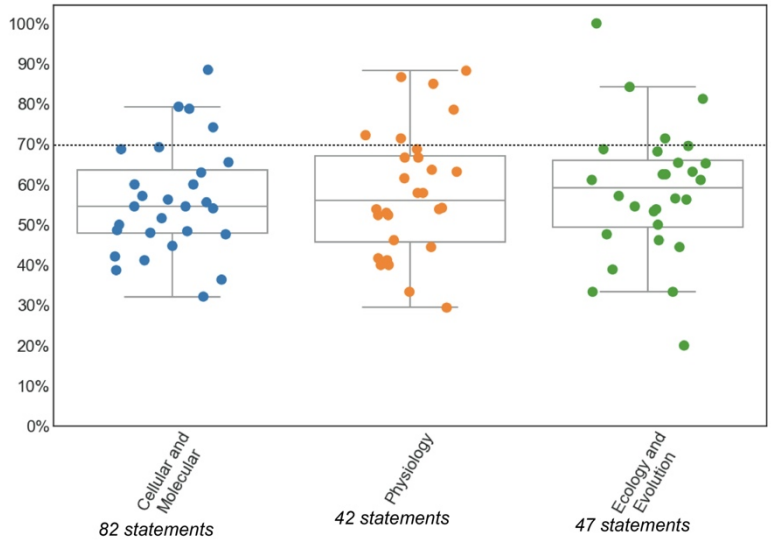


Figure D2 - Median, 1st and 3rd quartiles of percent correct answers for each of the core areas of *Biology* in the GenBio-MAPS survey. The number of questions in each of the core area is presented below its respective label. The dashed line denotes a score of 70% correct answers, and scores at or above the dashed line indicates mastery. Colored dots represent the performance of each student in each of the main subject areas.

Student performance in each of the 175 GenBio-MAPS statements is presented in the Annex I document (located after the Appendix). All students provided correct assessments of the following statements: “The HIV strain that makes this altered protease could be resistant to drugs designed to

block the function of the normal protease." (correct answer: True; Core concept: Structure and Function; Subject area: Cellular and Molecular Biology); "During this 15-year period, both bacterial strains have the capacity to accumulate genetic changes more rapidly than birds." (correct answer: True; Core Concept: Evolution Ecology and; Subject area: Evolution); "Normal SRY protein will be more likely to directly activate genes than the mutant SRY protein." (correct answer: True; Core Concept: Structure and Function; Subject area: Cellular and Molecular Biology); and "Under normal conditions, corticosterone levels in the blood will eventually return to their original levels once the initial stimulus is removed." (correct answer: True; Core Concept: Systems Thinking; Subject area: Physiology). In turn, the statement with the least number of correct assessment (only 9% of answers) was "If a field of clover is sprayed with a chemical that cannot be broken down, over time grasshoppers will likely accumulate a higher concentration of this chemical than hawks." (correct answer: False; Core concept: Transformation of Energy and Matter; Subject area: Ecology and Evolution).

The EcoEvo-MAPS asked students to evaluate 63 statements (30 Ecology-related statements; 33 Evolution-related statements). The average percentage of correct answers for the approximately 27 valid responses ranged from 54% in Ecology to 52% in Evolution, with maximum scores of 90% in Ecology and 81% in Evolution. Similar to the GenBio-MAPS results, only 3 students scored at or above 70% (mastery level) in the EcoEvo-MAPS survey.

When subdivided by *Vision and Change* Core Concepts, *Structure and Function* was the only Core Concept for which most students demonstrated mastery (74% average score), with quite a few students scoring at 100%. Average scores for all other Core Concepts ranged from 36% for *Information Flow* to 58% for *Systems Thinking* (Figure D3). Students performed the worst in two areas, *Information Flow* and *Transformation of Energy and Matter*, with average scores of 36% and 42% respectively.

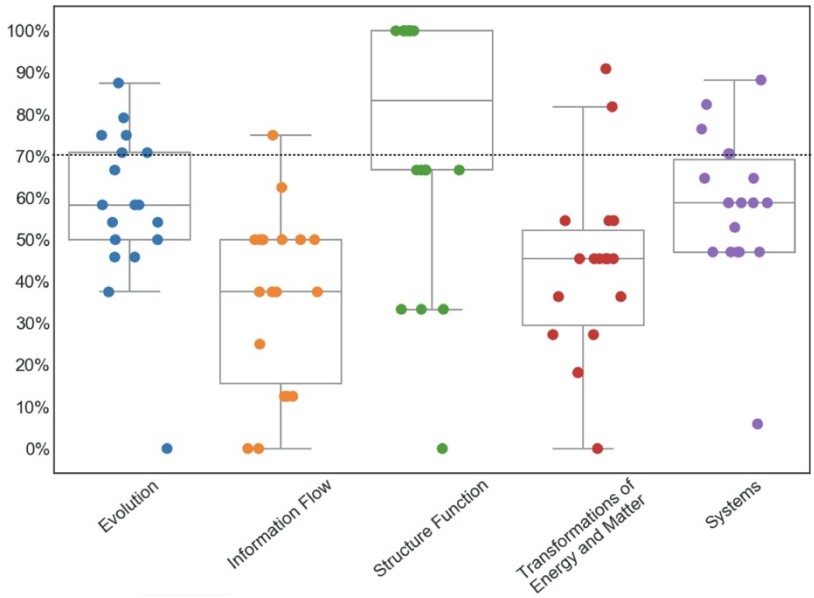


Figure D3 – Median, 1st and 3rd quartiles of percent correct answers for each of the core concept areas of *Vision and Change* in the EcoEvo-MAPS survey. The dashed line denotes a score of 70% correct answers, and scores at or above the dashed line indicates mastery. Colored dots represent the performance of each student in each of the five *Vision and Change* core concept areas.

In terms of major Ecology and Evolution Conceptual Themes (*Heritable Variation, Modes of Change, Phylogeny and Evolutionary History, Biological Diversity, Populations, Energy and Matter, Interactions with Ecosystems, and Human Impact*), average student performance ranged from 77% in

Biological Diversity to 36% in *Heritable Variation* (Figure D4). Other than *Biological Diversity*, students performed best in *Interactions with Ecosystems* (67%) and *Phylogeny and Evolutionary History* (61%) while the worst student performance was observed in *Heritable Variation* (36%), *Energy and Matter* (42%) and *Populations* (49%). Except for the Conceptual Theme "Biological Diversity," student average scores were below mastery level (70%) for all other categories (Figure D4).

When the Four Dimensions of Ecology Education (4DEE) framework were assessed, average student performance remained, for the most part, below mastery level (70%), except for two aspects of *Dimension 1: Core Ecology Concepts* (*Communities and Biomes*) (Figure D5). The lowest average student performance was on *Dimension 3: Human-Environment Interactions* (42%), while the highest was on *Dimension 1: Core Ecology Concepts* (54%, Figure D5).

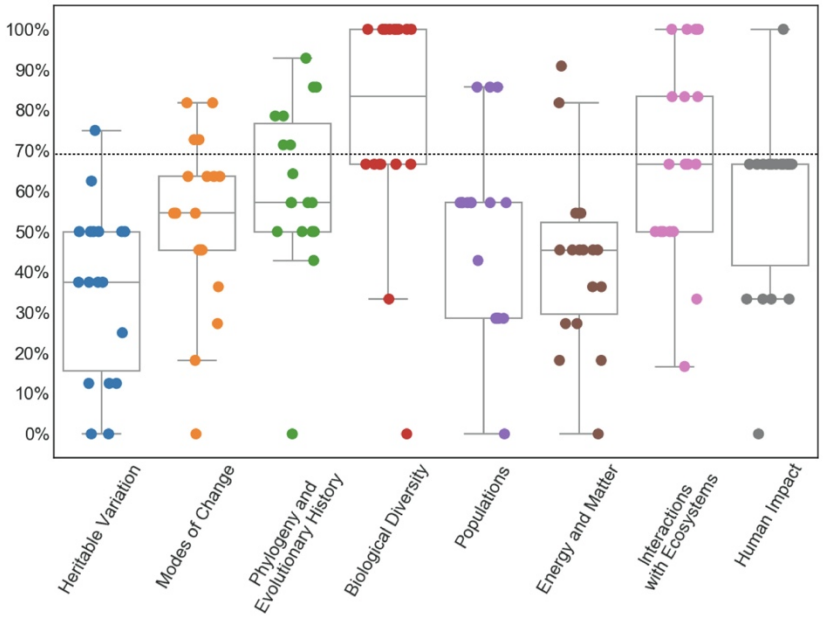


Figure D4 - Median, 1st and 3rd quartiles of percent correct answers for each of the Ecology and Evolution Conceptual Themes in the EcoEvo-MAPS survey. The dashed line denotes a score of 70% correct answers, and scores at or above the dashed line indicates mastery. Colored dots represent the performance of each student in each of the main subject areas.

Student performance in each of the 63 EcoEvo-MAPS statements is presented in the Annex II document (located after the appendix). The following statements had the greatest percentage of correct answers (88%): "Along the spectrum of symbiotic relationships, the association between this worm and the bacteria is closer to mutualism than parasitism." (correct answer: Likely; Core Concepts: Structure and Function, Interactions within ecosystems and Communities, Systems Thinking); "Climates are more similar at B and D than at A and B." (correct answer: Likely; Core Concepts: Systems Thinking, Biological diversity, Biomes, Designing & Critiquing Investigations); "The total number of plant species increased over the 15 years." (correct answer: Likely; Core Concept: Systems Thinking, Biological diversity and Communities, Designing & Critiquing Investigations); "Plants that colonized the plot in year 15 are better competitors for space and resources than plants that colonized the barren plots in year 1." (correct answer: Likely; Core Concepts: Systems Interactions within ecosystems and Communities, Systems Thinking); "More information is required to determine if the difference in number of feeding appendages between species C and D are

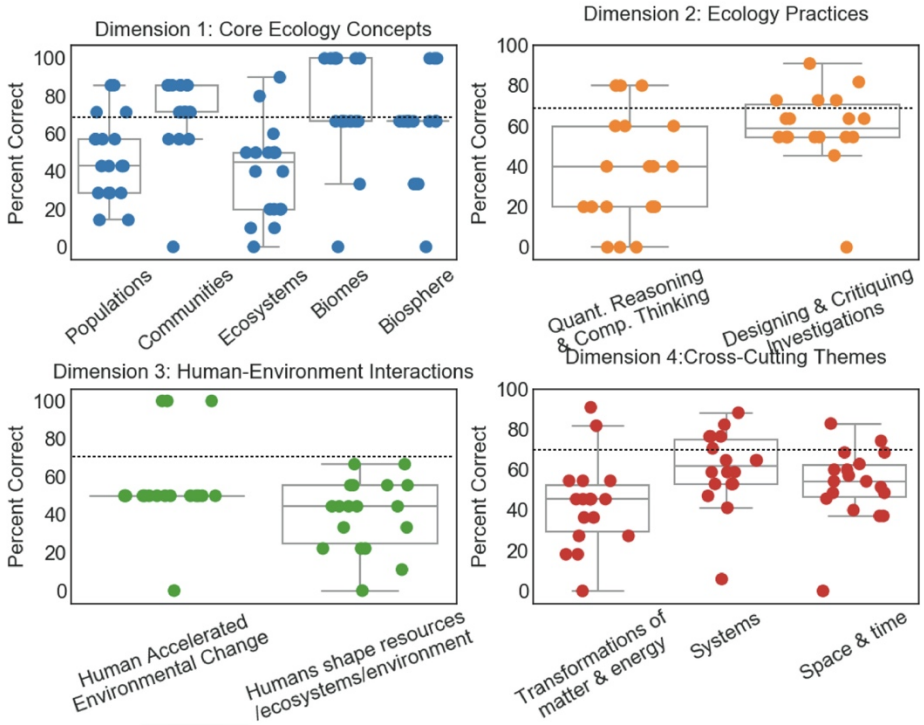


Figure D5 - Median, 1st and 3rd quartiles of percent correct answers for each of Four Dimensions of Ecology Education (4DEE) framework in the EcoEvo-MAPS survey. The dashed line denotes a score of 70% correct answers, and scores at or above the dashed line indicates mastery. Colored dots represent the performance of each student in each of the main subject areas.

adaptations." (correct answer: Likely; Core Concepts: Evolution, Modes of change, Space & Time); "Tree #2 shows marmosets and howler monkeys sharing a more recent common ancestor than orangutans and howler monkeys." (correct answer: Likely; Core Concepts: Evolution, Phylogeny and evolutionary history, Space & Time). In turn, no correct assessments were observed for statement "A new allele appearing in an isolated population of these worms is evidence for genetic drift." (correct answer: Unlikely; Core Concepts: Evolution, Modes of change, Space & Time).

Limitations: The results presented here, although interesting and somewhat informative, are limited by various factors. First, it is possible that the lack of a significant incentive for participation led not only to relatively low participant numbers but also to a lack of commitment in answering the survey. Thus, the accuracy of these data in terms of real student learning is uncertain, since there are no other data points to compare them to. In practice, BIOL 320 is not be the best time across the biology curriculum for student assessment. BIOL 320 is the fourth required course within the biology core curriculum, and is still very early in the bio major academic career. At this point, most bio majors are still developing their understanding of Biology core concepts, and these data might more accurately reflect that.

Recommendations for Program Improvement: The Department should expand this assessment throughout the Program in order to identify where in our Roadmaps we are failing to support student mastery of core biology concepts. In addition, the Department should review the current Long-Term Assessment Plan, or create a department-specific assessment plan, in order to promote a more granular, and potentially more accurate, picture of student learning outcomes during their time at Cal State East

Bay. Also, students should receive incentives for their participation so that a more accurate picture of their understanding of biological concepts can be achieved.

Next Step(s) for Closing the Loop: It is possible that the creation of a biology-wide capstone course, including students from all concentrations, can provide not only an opportunity for students to engage with one-another but also to integrate knowledge across biological disciplines. This capstone course would be organized around interdisciplinary research projects, intentionally involving students from different concentrations. It would also give the Department of Biological Sciences the opportunity to more accurately assess student knowledge closer to graduation, and more likely at mastery level.

Other reflections: The Bio-MAPS surveys used here have proven to be effective tools for biology-related concept assessment. They provide a straightforward way to deploy Program-level, large scale assessments, and their ease-of-use can potentially lead to the engagement of many Biology faculty. Likewise, reports are automatically generated by these tools, and they provide an easy way to quickly analyze the data to reveal relevant information regarding students understanding of biological concepts.

II-B. SUMMARY OF ASSESSMENT – GRADUATE PROGRAM

A. Program Learning Outcomes (PLO)

Students graduating with a M.S. in Biological Sciences from Cal State East Bay will be able to:

1. *Demonstrate a broad and sophisticated understanding that contributes to biological concepts and principles across all levels of biological organization, from ions to ecosystems (ILO 1,2,6);*
2. *demonstrate expertise in a specific area of biological science (ILO 6);*
3. *independently apply the scientific method to formulate testable biological hypotheses, analyze empirical data, and synthesize the results of the analysis (ILO 1,2,6);*
4. *clearly communicate the design and results of an observational or experimental analysis in a variety of formats, including the graduate thesis, scientific paper, scientific poster, and oral presentation (ILO 1,2,6);*
5. *gather and evaluate primary scientific literature and judge the value of the information presented in relation to particular biological questions (ILO 1,6).*

B. Program Learning Outcome(s) Assessed

Instrument: For the M.S. program we used the “Inquiry and Analysis Rubric” and the “Oral Communication Rubric” to assess the oral defense, a capstone event in partial fulfillment of the Master of Science Degree. A copy of these rubrics is included in the Appendix (Fig. A10). These rubrics are based on the VALUE rubrics developed by teams of faculty experts representing colleges and universities across the United States. The Value Rubric Development Project was sponsored by the Association of American Colleges and Universities.

Sampling Procedure: The combined “Inquiry and Analysis" and "Oral Communication" rubric was applied to all 11 M.S. students that scheduled an oral defense in during AY 2020-21. The oral defense is one of the final requirements that our M.S. students complete. By the time a student schedules the oral defense, the University Thesis has been written and submitted for format review.

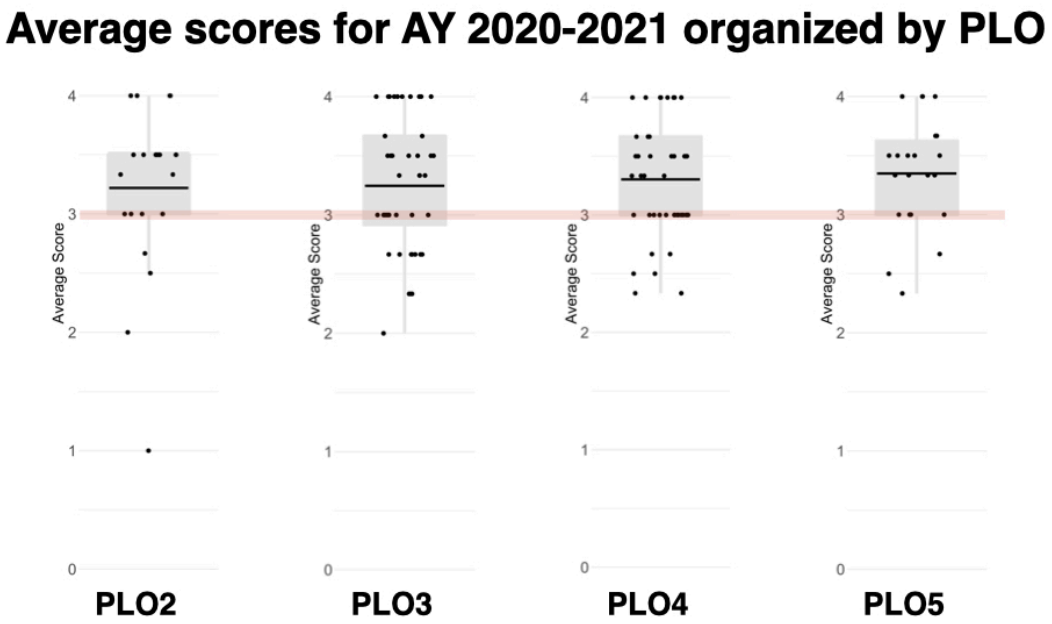
Data Collection: For the M.S. program, all three committee members (including the thesis advisor) are tasked to complete a combined “Inquiry and Analysis" and "Oral Communication" rubric just after the

completion of the oral defense by the student. The thesis advisor then collects the completed rubric forms and submits these documents to the Graduate Coordinator (Maria Gallegos). Upon receipt, the graduate coordinator forwards a Completion Memo to the University Graduate Evaluator. This year, a majority of students (n=7) were reviewed by three faculty members. Where that failed, two faculty members submitted an assessment. We are hoping to get better compliance in the coming years as the assessment form has now been converted to a Google Form and can now be submitted online (Link: https://docs.google.com/forms/d/e/1FAIpQLScK-3JmxzQKct2i2TLc-zrJoirCol6LoRW19tJjIIv59qLSRg/viewform?usp=sf_link)

Data Analysis: For the M.S. program, the results shown in C (Summary of Assessment Results) include all individual data points (filled black circles). The black horizontal line represents the average. The gray boxes represent the first and third quartile and the vertical lines represent the minimum and maximum. Figures C1 through C3 below include data for all 11 students evaluated in AY 2020-21.

C. Summary of Assessment Process

Main Findings: For the M.S. program, we aim for all of our students to score at 3 (proficient) or above for all PLOs assessed. By looking at the data for individual PLOs assessed (Figure C1), you can see that on average we are meeting our goal. That said, the same graph shows that some students are still scoring between 2 and 3 (2= basic) for PLOs 2, 3 and 4. In fact, one student scored a 1 for PLO2 (*demonstrate expertise in a specific area of biological science).* In Figure C2, the average earned score for individual assessment criteria is provided. This data demonstrates that on average, we again are meeting our goal of 3 or above. This year, two data points stand out in the category of "Background Knowledge". One student scored a one and another scored a two. And in fact, the average score for background knowledge was the lowest among all the criteria assessed. This might hint at a larger problem that needs to be address. Finally, when evaluating the performance of individual students (Figure C3), one can see that four of the eleven students (1, 8, 10 and 11) earned an average score below 3. In summary, while the data looks acceptable on average, we can still make improvements for individual students. See "Next Step(s) for Closing the Loop".



PLO2 through PLO5:

2. Demonstrate expertise in a specific area of biological science.
3. Independently apply the scientific method to formulate testable biological hypotheses, analyze empirical data, and synthesize the results of the analysis.
4. Clearly communicate the design and results of an observational or experimental analysis in a variety of formats, including the graduate thesis, scientific paper, scientific poster, and oral presentation.
5. Gather and evaluate primary scientific literature and judge the value of the information presented in relation to particular biological questions.

Figure C1. Average rubric score for each PLO evaluated. Please note that PLOs were evaluated by more than one criteria (see rubric in Appendix and list of individual criteria in Figure C2). The red line marks the position of proficient.

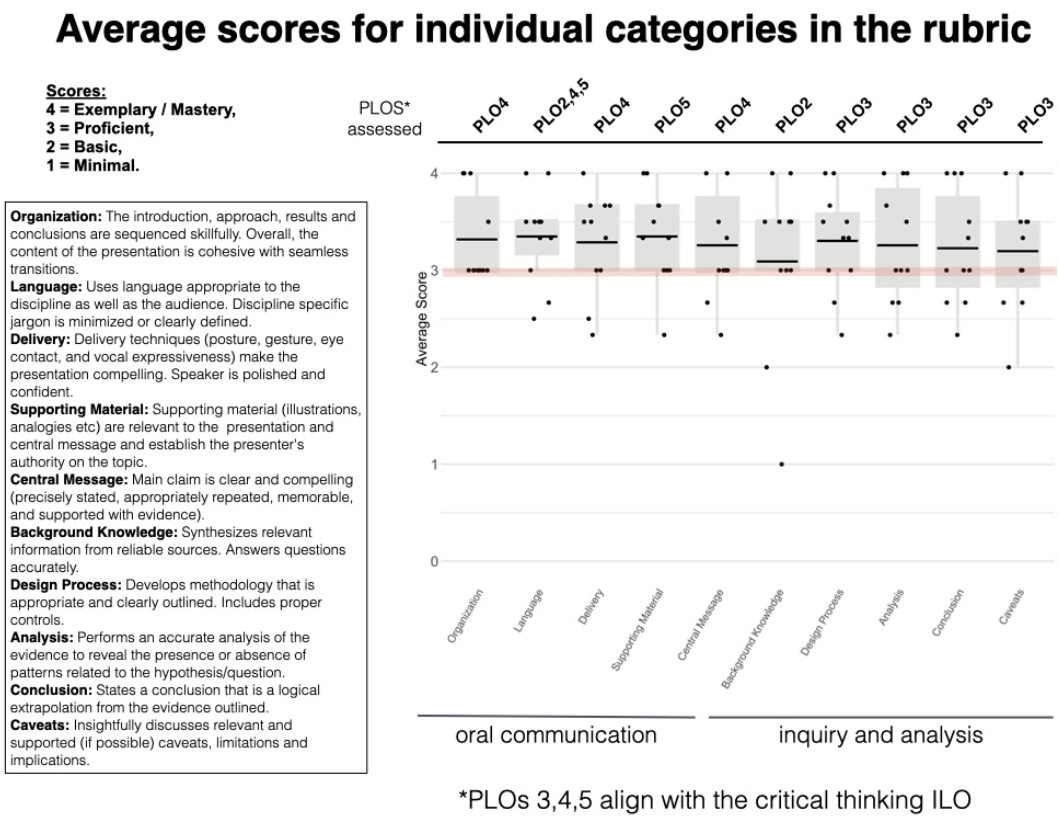


Figure C2. Average rubric score for each criteria outlined in the rubric. A list of categories listed in the rubric is found at right. The red line marks the position of proficient.

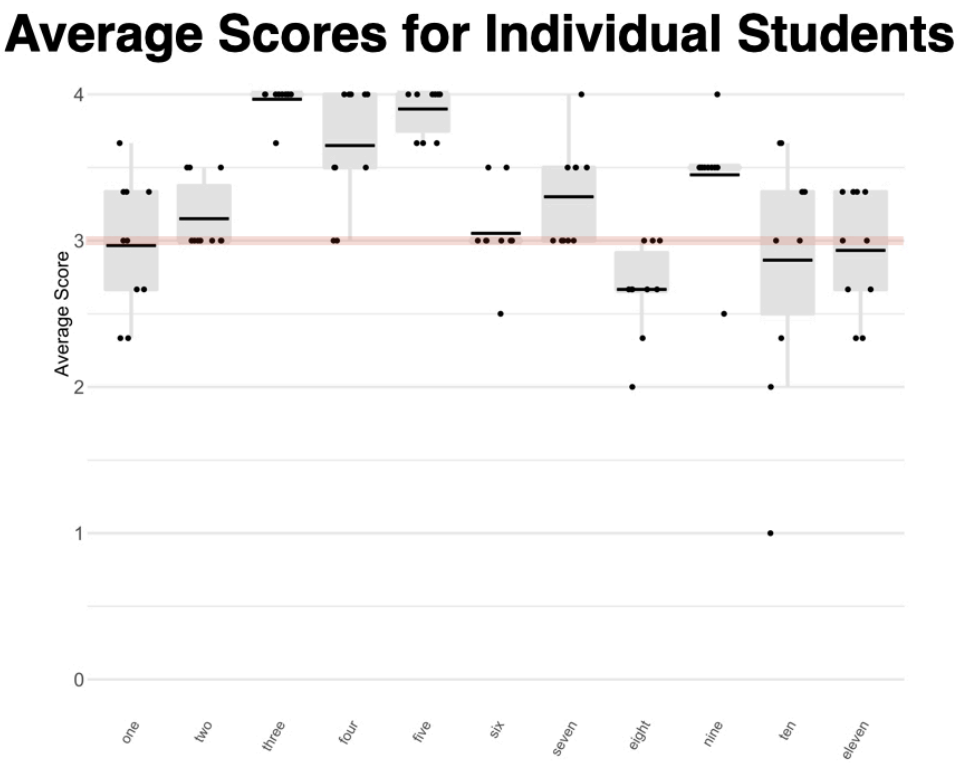


Figure C3. Average scores for each student. Students were numbered 1-11 from left to right. The red line marks the position of proficient.

D. Summary of Assessment Results

Recommendations for Program Improvement: We are aware of the areas in which our students require additional instruction and experience, and have decided upon steps that should be taken to improve student outcomes (see Next Step(s) below).

Next Step(s) for Closing the Loop: During our last two program report reviews we had decided that our students needed a formative assessment prior to the oral defense so that we could identify students that are struggling with specific program learning outcomes. The idea was to address these issues before struggling students were too far along in their thesis studies. The faculty discussed the possibility of instituting a departmental requirement that students must meet with committee members on a per semester basis to demonstrate progress towards the completion their degree courses and thesis research. Unfortunately, implementation of this plan remains inconsistent and many faculty argue that one meeting a semester would take too much time away from other responsibilities. That said, some faculty have started meeting with students during the proposal writing stage (this typically occurs during the Spring or Summer of or after the first year). This may be a reasonable compromise for now. We still believe regular meetings would make an important difference to many MS students progressing through our program. This year, we will promote enforcement by making concrete changes to the Proposal Submission Form. Going forward it will require each committee member to input the date of the required student faculty meeting in addition to the faculty signature. By placing it on the Submission form students will also be reminded that this meeting is required (See Figure A11).

We also mentioned previously that our semester curriculum now includes a year-long foundations course (1 unit/semester) that is designed to explicitly teach our graduate students how to perform an effective literature review, communicate science (oral and written), gather and evaluate scientific data, and identify assumptions, caveats and limitations of their proposed research. With two years of experience with these two courses behind us, we now realize that some important changes need to be made. The course description for 601A states, "*Foundations of Master's level skills needed to complete a research thesis. Application of the scientific method in the context of thesis formulation, experimental design, and accessing/evaluating scientific literature. Involves critical review of sample thesis proposals and drafting original thesis proposal.*" While the 601B course description states, "*Foundations of Master's level skills for effectively communicating scientific information. Application of the scientific method, in the context of communicating scientific findings and evidence-based conclusions. Emphasizes strategies in the presentation of scientific content and data to various audiences*." We decided that it is too premature to ask our first semester students to start working on a research proposal. The students need to gain more practical skills that will help them with that effort. Thus, we tentatively plan to reverse the order of these foundation courses and increase the proposal writing course to 2 units. Moreover, by making the second semester foundations course more about formulating a strong hypothesis and writing the proposal, we can use this as an opportunity to perform a formative assessment to see if and how our students are improving as the progress through the program.

Other Reflections: We are also confident that the modifications we are making to our year-long course in the curriculum that specifically focuses on the PLOs of the program will have a positive impact on the success of our M.S. students.

Assessment Plans for Next Year: In general, the faculty continue to value the rubric as an effective measure for assessing if our students are meeting our program learning outcomes. Thus, we plan to continue to use this same rubric to assess our MS students during the oral defense. By using the same rubric year after year, we will increase our statistical power and be able to evaluate if any of our programmatic changes make a difference in student outcomes. That said, we need to continue to have departmental discussions about what our expectations are for our MS students so that the data can be trusted from year to year. Also, we plan to begin to implement a formative assessment as students pass through the second semester foundations course. Then we can add longitudinal data to these reports as they become available.

Appendix

Program Learning Outcomes:

1. Demonstrate a broad and sophisticated understanding that contributes to biological concepts and principles across all levels of biological organization, from ions to ecosystems.
2. Demonstrate expertise in a specific area of biological science.
3. Independently apply the scientific method to formulate testable biological hypotheses, analyze empirical data, and synthesize the results of the analysis.
4. Clearly communicate the design and results of an observational or experimental analysis in a variety of formats, including the graduate thesis, scientific paper, scientific poster, and oral presentation.
5. Gather and evaluate primary scientific literature and judge the value of the information presented in relation to particular biological questions.

A description of an exemplary score is provided for each criteria listed below. An exemplary score is obtained for a given criteria when the description is true. A proficient score is obtained when the description is mostly true. A basic score is obtained when the description is somewhat true. ***Scores: 4 = Exemplary / Mastery, 3 = Proficient, 2 = Basic, 1 = Minimal.** *The rubrics below are modified from the VALUE RUBRICS.*

ORAL COMMUNICATION RUBRIC (PLOs 2,4,5):

Criteria	Capstone / Mastery	SCORE*	PLO
Organization of the Presentation	The introduction, approach, results and conclusions are sequenced skillfully. Overall, the content of the presentation is cohesive with seamless transitions.		4
Language	Uses language appropriate to the discipline as well as the audience. Discipline specific jargon is minimized or clearly defined.		2, 4, 5
Delivery	Delivery techniques (posture, gesture, eye contact, and vocal expressiveness) make the presentation compelling. Speaker is polished and confident.		4
Supporting Material	Supporting material (illustrations, analogies etc) are relevant to the presentation and central message and establish the presenter's authority on the topic.		5
Central Claim(s)	Main claim is clear and compelling (precisely stated, appropriately repeated, memorable, and supported with evidence).		4

INQUIRY AND ANALYSIS RUBRIC (PLO 3):

Criteria	Capstone / Mastery	SCORE*	PLO
Hypothesis/Question (not used for Thesis Defense)	Develops a creative, manageable and testable hypothesis or question related to a topic that is significant yet poorly understood.		3
Background Knowledge	Synthesizes relevant information from reliable sources. Answers questions accurately.		2
Experimental Design	Develops methodology that is appropriate and clearly outlined. Includes proper controls.		3
Accurate Analysis	Performs an accurate analysis of the evidence to reveal the presence or absence of patterns related to the hypothesis/question.		3
Logical Conclusions	States a conclusion that is a logical extrapolation from the evidence outlined.		3
Recognizes Limitations and Implications	Insightfully discusses relevant and supported (if possible) caveats, limitations and implications.		3

Figure A10. Rubric used in assessment of M.S. student oral defense of thesis.

Department of Biological Sciences

GRADUATE STUDENT APPLICATION for M.S. Research Proposal

(Proposal guidelines are on the back of this form)

Date: _____

Name: _____ Net ID: _____

Address: _____

Title of Research Proposal (include your proposal with your submission):

_____

_____

Major Advisor:	Signature:	Date:
_____	_____	_____
Committee Members (please print):	Meeting Date*:	Signature:
_____	_____	_____
_____	_____	_____

**Each committee member is required to meet with the named student to discuss the proposal prior to the submission of the final draft. Either an individual meeting or a meeting that includes the entire committee are acceptable. Input the date of the meeting in the space provided.*

Graduate Coordinator Signature (last to sign):

_____ Date: _____

The Research Proposal must be emailed to the Graduate Coordinator by the first day of classes the semester a student plans to take thesis units (Biol 691).

Revised 2021

Figure A11. The Proposal Submission Form that now includes verbiage that requires faculty to input the date of the faculty student meeting that is required prior to submission of the Proposal Submission Form.