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 4 assessment focused on PLO2 (*Apply quantitative reasoning to explain biological phenomena and to address biological problems*. PLO2 aligns to ILO 1 (***Thinking and Reasoning*** *- Think critically and creatively and apply analytical and quantitative reasoning to address complex challenges and everyday problems*). In order to assess this program learning outcome, the department used BioSQUARE[1], a validated assessment tool developed by a group of researchers with student data collected from 12 higher-education institutions across the country. Biology majors enrolled in BIOL320 in Fall 2024 and Spring 2025 were encouraged to participate in this assessment.

C. Summary of Assessment Process

Instrument: The BioSQUARE survey has a total of 29 questions, divided into three main topics: the *Algebra, functions and modeling* section contains a total 9 questions, the *Statistics and Probability* section contains a total of 8 questions, and the *Visualization* section contains a total of 12 questions. Each question covers specific content within each of these 3 topics. Each question was aligned to a modified version of the CSUEB Quantitative Reasoning rubric based on the specific content of the question. A breakdown of the questions and their alignment to the modified CSUEB Quantitative Reasoning Rubric is provided in **Tables 1 and 2**. The complete survey was uploaded to Qualtrics and the link to the survey was shared with students in class.

Sampling procedure: All students enrolled in BIOL320 - Evolutionary Biology in Fall 2024 and Spring 2025 were given equal opportunity to participate in the survey. In Fall 2024, 23 students were enrolled in BIOL320, and 69 students were enrolled in BIOL320 in Spring 2025.

Data Collection and Analysis: A link to the survey was shared with students in class, and class time was dedicated to completion of the survey. In addition, students received extra-credit points for their voluntary participation in the survey. All valid responses to the BioSQUARE survey were used for assessment. Each BioSQUARE question was subsequently aligned to one of the following rubric criteria, based on the CSUEB ILO Quantitative Reasoning Rubric, as such: **Problem Formulation** (*translation of the*

[1] Stanhope L, Ziegler L, Haque T, Le L, Vinces M, Davis GK, Zieffler A, Brodfuehrer P, Preest M, M Belitsky J, Umbanhowar C Jr, Overvoorde PJ. Development of a Biological Science Quantitative Reasoning Exam (BioSQuaRE). CBE Life Sci Educ. **2017** Winter; 16(4):ar66. doi: 10.1187/cbe.16-10-0301. PMID: 29196427; PMCID: PMC5749968.

disciplinary/real-world problem into a QR context) - 5 BioSQUARE questions; **Representation/Visualization** (*depiction of quantitative information such as visual*) - 3 BioSQUARE questions; **Quantitative Analysis** (*selection and use of analytical method*) - 9 BioSQUARE questions; **Interpretation** (*description of the meaning of the results in the context of the original problem formulation*) - 10 BioSQUARE questions; **Implications** (*extension of potential application to broader context*) - 2 BioSQUARE questions. Competency was assessed based on the number of correct answers to the questions in each of the rubric categories. For the criteria Implications, students were only assessed based on 3 competency levels (4, 3, and 2) since there were only 2 questions aligned to this rubric criteria. For a breakdown of rubric categories and competency levels, please refer to **Table 1**.

D. Summary of Assessment Results

Main Findings: A total of 79 valid responses were collected, with 23 responses from Fall 2024 (100% of the student population) and 56 responses from Spring 2025 (81% of the student population). Distribution of student performance is shown in **Figure 1** below. Aside from *Implications*, which overestimates competency level due to the limited number of assessed questions, highest student performance was observed for criteria *Interpretation* (59.5% of students at or above competency) and *Quantitative analysis* (53.1% of students at or above competency). *Problem formulation* had the lowest level of student competency, with only 40.5% of students at or above competency. For *Problem formulation,* only 1 of the 5 questions showed competency in more than half of the student population. The content of these questions with poor student performance focused on the *meaning of p-value, statistical significance, and the relationship between p-value and effect*.

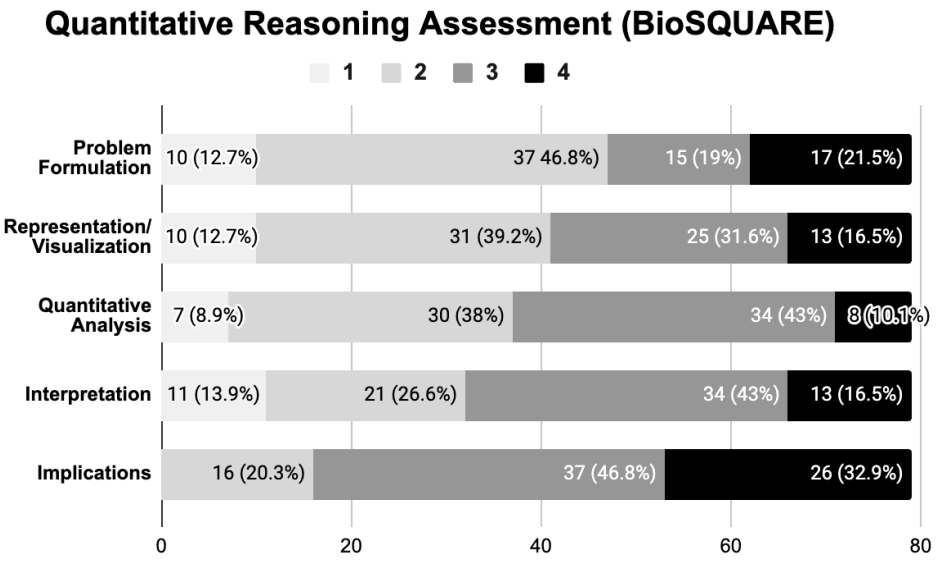

Figure 1 - Quantitative Reasoning assessment results. Each rubric category was assessed based on 4 competency levels, with the exception of Implications which had only 3 competency levels. Competency levels 3 and 4 reflect student artifacts that met or exceeded competency, while levels 1 and 2 are below competency and demonstrate need for further development of the specific competency(ies). Numbers followed by percentage reflect the number and proportion of students in each of the competency levels for each of the rubric criteria. Rubric criteria were modified from the CSUEB Quantitative Reasoning Rubric, and a full description of each criteria, as well as the achievement for each competency level and their alignment to the BioSQUARE questions can be found in **Table 1** below.

Overall, questions with the highest number of correct answers in each of the rubric categories varied in content (**Table 2**). For *Problem formulation*, the best performance was on question 28 (*Understanding relationship between data, Research Question, and plot*), with 61% of students choosing the correct answer. For *Representation/Visualization*, the best performance was on question 5 (*Translating summary statistics to a distribution*), with 71% of students choosing the correct answer. For *Quantitative Analysis* the best performance was on question 2 (*Understanding variation in measurements*), with 80% of students choosing the correct answer. In fact, this was the question with the largest number of correct answers out of the 29 BioSQUARE survey questions. For *Interpretation* the best performance was on question 20 (*Interpreting relationships between variables from a line plot*), with 75% of students choosing the correct answer, and for *Implications* the best performance was on question 24 (*Predicting from a genetic model*), with 58% of students choosing the correct answer. In turn, some of the most challenging questions (e.g., Q7, Q14, Q15, Q25) focused on content such as *Interpreting plots of logarithms*, *Understanding p-value*, and *Graphing a nonlinear function*. A complete description of student performance in each of the questions, and their respective content and rubric category is presented in **Table 2**.

Recommendations for Program Improvement: Overall, the BioSQUARE survey was an appropriate tool to assess quantitative reasoning skills among biology majors. The results of this assessment were no surprise to the department, and faculty have long discussed ways in which biology majors would benefit from more exposure to quantitative reasoning. Based on this assessment data, BIOL320 students were challenged by many quantitative reasoning topics, particularly *interpreting plots of logarithms*, *graphing a nonlinear function*, *meaning of p-value, statistical significance,* and *the relationship between p-value and effect*, and would benefit from sustained development of these skills throughout their academic career in the department. The inclusion of quantitative reasoning across the curriculum would promote consistent exposure of students to these topics, and provide multiple opportunities for development and mastery of QR skills. As an additional attempt to address this need, the department developed a new course, BIOL 200 - Biological Reasoning, a GE-1B; Second Composition course focused on the use of case studies to teach critical thinking and scientific reasoning in biology. Despite the fact that BIOL200 is not a required course for our majors, but rather a recommended GE course, the department believes biology majors can greatly benefit from such a course. Together with other curriculum improvements in our required major courses, the department believes BIOL 200 can further support the development of QR skills.

Next Step(s) for Closing the Loop: The department is planning to offer BIOL 200 for the first time in the AY2026-27, and will work together with academic advisors to help biology majors enroll in BIOL200. Meanwhile, faculty are working on their courses to further add quantitative reasoning skills to their curricula, specifically focusing on the areas identified in this assessment as in need of improvement.

Other reflections: Although BioSQUARE has proven an excellent tool for assessing quantitative reasoning among biology students, assessment was conducted in BIOL320, a mid-career course for biology majors. BIOL320 is the last 'core course' taken by all biology majors, and is followed by many other concentration-specific 400-level required courses. These 400-level courses might further contribute to the development of quantitative reasoning skills, and assessing students at the end of their academic career in our major might provide further insight into how well our PLO2 is being met.

Table 1 - Modified CSUEB Quantitative Reasoning Rubric with competency-level assessment for each criteria (in bold) and alignment to BioSQUARE question items.

Modified CSUEB ILO Quantitative Reasoning Rubric

	4	3	2	1	BioSQUARE Items
Problem Formulation Translation of the disciplinary/real-world problem into a QR context (e.g., writing a hypothesis, a math model, quantitative instrumentation). Use and interpretation of quantitative data/information to identify or formulate a problem.	Formulation of the problem is comprehensive and placed in an appropriate quantitative context. (**4 or 5 correct answers**)	Formulation of the problem is adequate and placed in an appropriate quantitative context. (**3 correct answers**)	Formulation of the problem is limited; explanation of the context is somewhat incorrect or incomplete. (**2 or 1 correct answer**)	Formulation of the problem is incorrect or missing; explanation of the context is incorrect or incomplete. (**No correct answers**)	6, 26, 27, 28, 29
Representation/Visualization Depiction of quantitative information such as visual (e.g., figures, charts, tables, equations) and non-visual (e.g., audio, ADA accessible).	Accurate and appropriate display of quantitative information using academic vocabulary with correct symbols, units, scale, etc. (**3 correct answers**)	Mostly accurate and appropriate display of quantitative information. May contain minor errors in academic vocabulary, symbols, units, scale, etc. (**2 correct answers**)	Somewhat accurate and/or appropriate display of quantitative information. May contain major errors in academic vocabulary, symbols, units, scale, etc. (**1 correct answer**)	Inaccurate, inappropriate, or missing display of quantitative information. May contain major errors in academic vocabulary, symbols, units, scale, etc. (**No correct answers**)	5, 10, 25
Quantitative Analysis Selection and use of analytical methods (e.g., data analysis, solution technique).	Appropriate and accurate selection and use of analytic methods. (**8 or 9 correct answers**)	Mostly appropriate and accurate selection and use of analytic methods. (**5, 6 or 7 correct answers**)	Somewhat appropriate and/or somewhat accurate selection and use of analytic methods. (**3 or 4 correct answers**)	Inappropriate and inaccurate selection and use of analytic methods. (**2 or fewer correct answers**)	1, 2, 3, 4, 7, 8, 9, 13, 23
Interpretation Description of the meaning of the results in the context of the original problem formulation.	Appropriate and comprehensive explanation of the results obtained from the quantitative analysis in the context of the original problem. (**8, 9 or 10 correct answers**)	Mostly appropriate explanation of the results obtained from the quantitative analysis in the context of the original problem. (**5, 6 or 7 correct answers**)	Somewhat appropriate explanation of the results obtained from the quantitative analysis. Explanation of the context is somewhat incorrect or incomplete. (**3 or 4 correct answers**)	Inappropriate, inadequate, or missing explanation of the results obtained from the quantitative analysis. Explanation of the context is incorrect or incomplete. (**2 or fewer correct answers**)	11, 12, 14, 15, 17, 18, 19, 20, 21, 22
Implications Extension of potential application to broader contexts (e.g., predictive values, future directions, ramifications, clinical prognosis, professional and/or civic responsibilities).	Clearly identifies and explains substantive potential applications of the results and their broader impacts. (**2 correct answers**)	Adequately identifies and explains substantive potential applications of the results and their broader impacts. (**1 correct answer**)	Unclear or limited explanation of substantive potential applications of the results and their broader impacts. (**No correct answers**)	--	16, 24

Table 2 - Student Performance on BioSQUARE questions with Rubric alignment and BioSQUARE Item Content. Questions were color-coded based on student performance, calculated as the number of correct answers to each BioSQUARE question. Yellow - <50% of students chose the correct answer; Green - >50% students chose the correct answer.

BioSQUARE Question	Performance	Rubric Criteria	BioSQUARE Content
Q15	21	Interpretation	Interpreting plots of logarithms
Q29	22	Prob. Formulation	Understanding relationship between data, RQ, and plot
Q14	23	Interpretation	Interpreting plots of logarithms
Q7	23	Quant. Analysis	Understanding p-value
Q21	24	Interpretation	Interpreting trend in a choropleth map
Q25	24	Representation	Graphing a nonlinear function
Q13	28	Quant. Analysis	Translating between two graphs of data
Q23	34	Quant. Analysis	Relationship between summary statistics and statistical significance
Q17	35	Interpretation	Interpreting interaction effects from a plot
Q6	35	Prob. Formulation	Translating content to a statistical hypothesis
Q9	36	Quant. Analysis	Understanding relationship between p-value and effect
Q26	36	Prob. Formulation	Understanding relationship between data, RQ, and plot
Q27	37	Prob. Formulation	Understanding relationship between data, RQ, and plot
Q22	38	Interpretation	Interpreting variation in a choropleth map
Q10	39	Representation	Translating content to tabular summaries
Q3	41	Quant. Analysis	Understanding variation in log-transformed measurements
Q16	43	Implication	Predicting from a recursive model of population growth
Q24	46	Implication	Predicting from a genetic model
Q28	48	Prob. Formulation	Understanding relationship between data, RQ, and plot
Q11	49	Interpretation	Interpreting variation in a heat map
Q8	49	Quant. Analysis	Understanding p-value
Q12	50	Interpretation	Interpreting trend in a heat map
Q19	51	Interpretation	Interpreting relationships between variables from a line plot
Q18	53	Interpretation	Interpreting interaction effects from a plot
Q5	56	Representation	Translating summary statistics to a distribution
Q4	58	Quant. Analysis	Relating sample size to uncertainty
Q20	59	Interpretation	Interpreting relationships between variables from a line plot
Q1	61	Quant. Analysis	Compute probability from a two-way table
Q2	63	Quant. Analysis	Understanding variation in measurements