Assessment of Effectiveness of a Cross-Departmental Prerequisite and it's Role in Curricular Revision

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February 15, 2008

Narrative:

One of the four primary goals in the current CSUF Biology Department SOAP is:

> *Biology majors will gain knowledge and experiences in the basic methods, instrumentation and quantitative analytical skills used to conduct scientific research in biological science.*

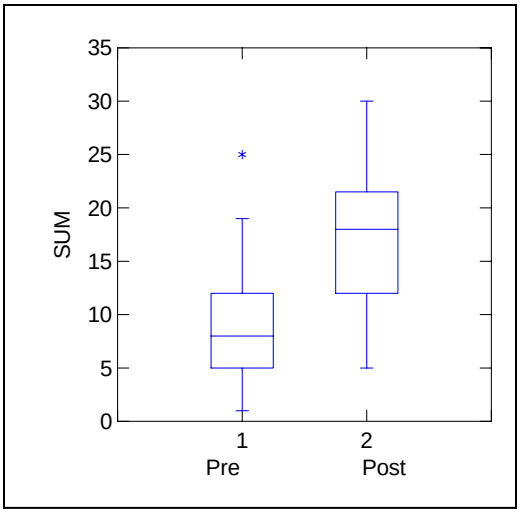
Biology curricula in general require that biology majors pass one or several mathematics courses in order for these students to develop quantitative skills. Current CSU-Fresno Department of Biology curriculum requires inter-departmental courses in both mathematics (Math 70 or 75) and statistics (Math 101 or Psych 42). Biology students are consistently frustrated by the challenge of translating this inter-departmental learning directly to their biology curriculum and training as biologists. At many universities the statistics course requirement is offered within the biology department.

The inter-departmental statistics course requirement in the CSU-Fresno biology curriculum has recently been challenged by a recent (2005) external departmental review. The review category of "Curriculum design and relevance to university mission" includes two main recommendations for the biology major core curriculum. The first is: "*The department should consider adding one course, [1]Biometry, to this core in place of Math 101 or Psych 42*". The provided rationale is that "*…a statistical methods course specific to the biological sciences would be much more meaningful to the students…and (emphasize) the growing importance of mathematical analyses in the life sciences*".

Biology students need effective training in biologically-relevant statistics and experimental design principles (Sahai & Ojeda 1999; Zolman 1999). Student performance and biology faculty classroom experiences (**Appendix 1**) demonstrate the frequent and wide-spread inability of biology majors to apply concepts delivered in the required Math 101 or Psych 42 courses as per the syllabi from these courses. The department consequently graduates students that are deficient in mathematical skills and more specifically biologically-relevant statistical skills. This does not reflect well on our department or our community-engaged university in general.

My personal experience with biology majors is based on several upper-division courses, all of which have statistics (Math 101 or Psych 42) as a prerequisite or gateway prerequisite. For example in the Biosc 130 (General Ecology) core course, since implementation of laboratory exercises based on the Innovative Instruction Proposal '*Infusing student-directed and active-learning into General Ecology Laboratories*' in 2002, a number of students have confided that they learned more statistics in this *biology* course than in their statistics course prerequisite.

[1]Biometry: The statistical study of biological data (American Heritage Dictionary)



To test this notion, I conducted an extremely basic pre- & posttest survey of relevant statistics terms and questions to the Fall 2007 Biosc 130 students (n=53). I used an ad hoc scoring rubric of: 0 = Left blank; 1 = Answer attempted but incorrect or minimally correct; 2 = Some knowledge of the term or issue; 3 = Excellent understanding of term or issue (not common). A maximum possible score was 39. The figure to the right demonstrates the highly significant ($t_{91,1}$=7.02; P<0.001) difference in pre- and posttest scores. However, this survey was cobbled from a version that I usually use in my graduate statistics course, and may not be robust to the principles of survey methodology. In addition, it did not control for within-student test differences and suffered from many blank responses. However, it does suggest to the need for a more complete, formalized, and well-planned assessment that can help diagnose the current problems with biology student understanding and application of biologically-relevant experimental design and statistical analyses.

Beyond this example, many biology faculty frequently spend class time teaching basic experimental design and statistical procedures to upper-division students; valuable class time that should be dedicated to the course subject matter. The biology faculty are clearly aware of biology majors' inability to effectively transfer knowledge that should have been gained in Math 101 or Psych 42 to their upper-division biology courses. What is not known is what to do about it. Thus, we currently are limited to self-reports in a situation where direct assessment measures are clearly needed. **The goals of this assessment project include quantification and documentation of statistical knowledge and skills gaps in biology majors, and diagnoses for solutions to bridge these gaps. In response to the external biology department review, this project will also survey the biology curricula of other CSU biology departments.**

b. Methodologies/procedures to implement

Assessing student learning generally requires more than one assessment measure (Siebert & McIntosh 2001; cited in Sundberg 2002). The primary assessment measure in this project will be a pretest/posttest in the Biosc 130 (General Ecology) course, which is a core course required of all biology students and has Math 101 or Psych 42 as a prerequisite. In this case, the goal is to use a survey or short pretest at the start of the course to assess relevant knowledge and skills from Math 101/Psych 42. The posttest at the end of the semester will provide a relative measure of change in relevant

knowledge and skills throughout the semester. Both will be limited to ~10-12 items and an anticipated completion time of ~15-20 minutes.

On February 14, 2008, I attended the CETL workshop '*Doing Survey Research*' (Ed Nelson, Sociology) in order to better understand the application of survey research as a direct measure of student learning and understanding. The session included methods for avoiding common survey instrument problems, including those based on assessing student knowledge and skills. For example, development process of this assessment plan will pay particular attention on avoiding survey bias, as found in a report of a CSU-Fresno assessment project funded during the 2005-2006 AY:

> ***Did you run into any problems? If so, what were they and how did you resolve them?*** *The students did not seem to take the exam as seriously as we had hoped although we did try to convey the importance of it. Students did not have an incentive to perform as best they can. It was not part of any course grade and, as a result, they do not appear to have applied all of their abilities to the exam. As noted previously, many questions were incomplete or simply left blank. The Department needs to determine why these questions were left blank, i.e., did the students run out of time? Did the students not know the material? Or, did the students just not attempt the questions? These questions are pertinent to a meaningful evaluation of the assessment exam. In one case, with Geology 104 (Scientific Writing), it was likely an issue of time and priorities for the students.*

This outcome will be avoided in two ways. First by informing the students that 10% of their lab grade is based on participation (as always) and that the assessments are part of participation. Secondly, the assessments will avoid written responses in favor of multiple-selection questions, which should greatly reduce the potential for an absence of responses.

A second project component and assessment tool will be student interviews. These interviews will be a formalized alternative to the dozens of discussions I've had with Biosc 130 students during office hours regarding their statistic course prerequisite. Soliciting volunteers will not be difficult, as they are quite eager to discuss this topic. Interviews will avoid the bias of involving the instructor in the process (Sundberg 2002). This will be achieved by hiring biology graduate students to conduct the short interviews, which can be done during 'down-time' in lab sections while experiments are running for example. Qualifications for graduate student interviewers will be prior completion of Biol 274 (Biometry).

The third project component is results of a survey of other CSU Biology programs for whether biology curricula include their own statistics course for their majors. This survey will be done via the internet or through telephone calls to departmental representatives as necessary.

Assessment plan development will also include review of the findings and recommendations of FLAG (Field-Tested Learning Assessment Guide; http://www.wcer.wisc.edu/nise/cl1). For example, one of the assessment techniques detailed in FLAG is 'Fault Finding and Fixing Tasks' (Swan & Ridgeway; http://www.flaguide.org/cat/math/fault/fault1.php). These tasks are assessment tools with the purpose of identifying student misconceptions about mathematics and statistics. Together, these tasks and other assessment tools can foster diagnosis of student misconceptions of biologically-relevant quantitative analyses that they cannot clearly understand or apply. Assessment plan development will also include consultation with CETL and the Office of Institutional Research, Assessment, & Planning (e.g. 'Voices of Experience: Assessment Advice from Cal State Fresno's Veteran Assessment Coordinators').

c. Anticipated impact of the project, including
i. improvements in curricula and teaching
ii. on-going benefits beyond the year developed

The results of this project will identify and help guide how biology faculty can address any quantitative analysis skill deficiencies among biology majors. These responses can occur at several levels. For example, at the level of teaching pedagogy in individual courses one finding may be that we need to take responsibility for increasing active learning and 'open-ended inquiry' exercises in our courses (McNeil & D'Avanzo 1996; Peterson & Jungck 1988). Except for the SOAP, the biology department currently lacks common guidelines for laboratory experiences of biology majors. The findings of this project would facilitate the development of teaching standards for experimental design and statistics in biology courses.

At another level, the findings of this project would guide biology curriculum changes, especially those suggested in the external departmental review. The opportunity to implement this assessment project is especially timely, as substantial curricular revision is underway in the biology department, largely motivated by findings and recommendations of the recent program review. The findings of this project will provide a valuable assessment and diagnostic tool in guiding the on-going curricular revisions. Thus, linking the proposed project with curricular revision ensures on-going benefits for the biology department and its majors.

Overall, teaching and curricular decisions aided by this assessment project may have a variety of outcomes. These include but are not limited to: a) the status quo, with no changes; b) modification of the way biology courses are taught; c) a biology course to supplement the current Math 101 or Psych 42 requirements; and d) replacement of the Math 101 or Psych 42 requirement with a Biometry-type course in the biology curriculum.

d. Project time line (to be completed by the end of the Spring 2009 term)

Development of an assessment plan and survey of CSU-wide biology curricula will take place during summer 2008. Student assessment (pre/post tests + interviews) will take place during the Fall 2009 semester. Data analysis and report generation will be completed during the Spring 2009 semester. I would like to have these activities completed in time for proposal submission to present this project at the 2009 Regional Conference on Excellence in Teaching & Learning.

Bibliography

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Appendix 1: Observations of biology faculty (who teach upper-division laboratory courses) regarding the adequacy of student training in quantitative analytical skills used to conduct scientific research in biological science courses.

Dr. Madhu Katti:
"I teach several upper division courses (Field Methods in Ecology, Biology of Reptiles & Birds) with significant lab components requiring students to carry out ecological research projects where they must employ rigorous experimental design and quantitative analysis. I often find that the majority of students need a significant refresher on basic statistical analysis and experimental design before they are able to conduct their project in these classes despite the fact that they have successfully completed the quantitative/statistical prerequisite courses (Math 101 and/or Psych 42)."

Dr. Larry Riley
"Since joining the biology department in 2005, I have completely rewritten the Comparative Vertebrate Physiology laboratory (PhyAn151L) exercises to be hypothesis driven. In contrast to the previous course design, the students are now required to statistically analyze their data and then present them to the class. I have noticed that the students enrolled in this class are not properly trained in biological statistical methodology. Indeed, several students have mentioned to me that if our department had offered a biological statistical course, it would have increased their understanding of biology in several of our laboratory courses."

Dr. Jason Bush
"In my experience, many of the fundamental mathematical skills are forgotten or simply not routine such that rather simple calculations of molarity and dilution for example, become challenging. Furthermore, my research program demands quantitative interpretation of mass spectra which often requires some higher level reasoning of informatics. When confronted with these manipulations, many students are at a loss for how to proceed. I would support a formal assessment of the program in this regard".

Budget:

Faculty Stipend (Summer 2008)	$3000
Graduate student interviewers	20 hrs at $15/hr = $300
Total Request:	$3300

CALIFORNIA
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FRESNO

February 15, 2008

To Whom it May Concern:

In an effort to address inefficiencies in our curriculum and address curricular issues raised during a recent biology department program review (2005), the biology department is undergoing major curricular revision. Several assessment activities are ongoing in order to best diagnose and guide changes in curriculum.

The proposal "*Assessment of Effectiveness of a Cross-Departmental Prerequisite and its Role in Curricular Revision*" submitted by Dr. Steve Blumenshine of our department is a critical element to address both our teaching pedagogy and curricular modification.

Specifically, this proposal addresses the suggestion in our program review that: "*The department should consider adding one course, biometry, to this core in place of Math 101 or Psych 42. A statistical methods course specific to the biological sciences would be much more meaningful to the students and help emphasize the increasingly interdisciplinary nature of biological research and the growing importance mathematical analysis in the life sciences.*"

However, we would like to better understand our options before implementing the suggested modification. Thus a comprehensive assessment of our students' knowledge and skills in relevant quantitative analyses is warranted. This objective also meets one of the four primary objectives in our SOAP: *Biology majors will gain knowledge and experiences in the basic methods, instrumentation and quantitative analytical skills used to conduct scientific research in biological science*.

In closing, I support the submitted proposal which will help guide our process of curricular revision. Please contact me if you need any further information.

Sincerely yours,

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Student Learning Outcomes Assessment Plan

Department of Biology
Undergraduate Bachelor of Science Degree Program
California State University, Fresno
Revised, February 2, 2006

Mission Statement:

To provide a diverse undergraduate program that matches the breadth and excitement of modern biology, develops critical thinking skills, and prepares students for the hundreds of career opportunities that use biology as a foundation.

Goals:

1. Biology majors will gain a broad background in the fundamental concepts of the Biological Sciences.

2. Biology majors will gain knowledge and experiences in the basic methods, instrumentation and quantitative analytical skills used to conduct scientific research in biological science.

3. Biology majors will develop critical thinking and communication skills, both oral and written, for purposes of conveying biological information to both professional scientists and the lay public

4. Biology majors will develop intellectual independence, scientific literacy and an appreciation for the connections between biological science and society.

CSU Fresno Biology Graduates will develop the knowledge, abilities and attitudes portrayed in the Department's stated goals and objectives:

Goal 1:
Biology majors will gain a broad background in the fundamental concepts of the Biological Sciences.

Objectives

1.1 Conceptual knowledge in Biology
For each area Biology majors will understand characteristics, relationships and mechanisms of change

1.1A	principles of:	evolution
1.1.B	" "	ecology and environmental biology
1.1C	" "	cell biology

1.1D " " genetics
1.1E " " molecular biology
1.1F " " physiology
1.1G " " biochemistry and metabolism
1.1H " " biodiversity
1.1I " " developmental biology
1.1J " " organismal biology
1.1K " " history of science and biology
1.1L " `" scientific method/process

1.2 Unifying themes
1.2A evolutionary patterns and processes
1.2B energy transformations and flow
1.2C nutrient cycles
1.2D homeostasis and equilibria
1.2E molecular information flow
1.2F structure-function relationships
1.2G hierarchy of biological organization
1.2H developmental patterns and processes
1.2I complexity of interactions in biological systems

Goal 2

Biology majors will gain knowledge and experiences in the basic methods, instrumentation and quantitative analytical skills used to conduct scientific research in biological science.

Objectives:

2.1 Scientific Method
2.1A knowledge of the hypothetico-deductive method of inquiry
2.1B ability to apply the scientific method to biological questions
2.1C ability to generate a hypothesis
2.1D ability to design an experiments

2.2 Analytical and quantitative skills
2.2A make appropriate measurements and create data sets
2.2B graph and display data
2.2C objectively analyze data
2.2D interpret results of experiments

2.3 Biological information skills
2.3A understand and evaluate primary biological literature
2.3B integrate published information in oral and written communication
2.3C use biological databases

2.4 Lab and field skills
2.4B use appropriate equipment and instrumentation
2.4C safety procedures

2.5 Teamwork skills
2.5A work cooperatively in a group
2.5B solve problems in a group

Goal 3:

Biology majors will develop critical thinking and communication skills, both oral and written, for purposes of conveying biological information to both professional scientists and the lay public.

Objectives:

3.1 Critical thinking and problem solving skills
- 3.1A develop an argument and support it
- 3.1B recognize and uses deductive and inductive reasoning
- 3.1C integrate concepts within and among disciplines
- 3.1D solve problems
- 3.1E distinguish between data and inferences based on data

3.2 Communication skills
- 3.2A communicate effectively orally
- 3.2B communicate effectively with scientific writing

Goal 4:

Biology majors will develop intellectual independence, scientific literacy and an appreciation for the connections between biological science and society.

Objectives:

4.1 Embraces lifelong learning, has career knowledge
- 4.1A capable of self-directed learning
- 4.1B possess a sustained interest in biology
- 4.1C knowledge of potential career paths

4.2 Scientific literacy
- 4.2A able to distinguish science from pseudoscience
- 4.2B views science as a way of viewing the world and not just a collection of facts
- 4.2C understands limitations of science
- 4.2D applies scientific thinking to everyday problems

4.3 Biology and society
- 4.3A helps public to make informed decisions about biodiversity and biological resources
- 4.3B appreciates relevance of biology to society
- 4.3C understands and appreciates connectedness of science, society and history
- 4.3D can identify and evaluate ethical issues in biology

The Biology Department at CSU Fresno has a diverse program of instruction in Biology that spans organismal biology, ecology and evolutionary biology through physiology, cellular and molecular biology. Because of this tremendous diversity of instruction, the only courses in the instructional curriculum that all majors receive are the Biology Core courses. In addition, many of our students (perhaps as high as 60%) are transfer students from the California community colleges. Consequently, less than 50% of the department's majors experience the seven-course Core as delivered by the department and its faculty. Given these limitations, the focus of the department's outcomes assessment will primarily be the Core, but assessment will also occur in some non-core upper division Biology courses.

Assessment will be conducted in the Department of Biology that continues to have two major questions in mind: 1) Do the content and delivery in the Core courses adequately address the goals and objectives of the department? and 2) Do the instruments used to assess student learning (term papers, laboratory reports, mid-term lecture exams etc.) appropriately measure the learning goals and objectives of the department? In the event that assessment activities do not adequately measure learning objectives, the Department will strive to identify other assessment instruments and/or activities that do.

Assessment activities for the undergraduate majors program in the Department of Biology will consist of six direct measures and two indirect measure of student learning. These include analysis of Pre- and Post-tests, primary traits analysis of assignments in two upper division Core courses and one upper division microbiology course, pipeline analysis of student status and demographics and an alumni survey.

Assessment Activities:

Direct Measures of Student Learning:

1. Pre and Post Test

A pre- and post-test to assess how well biology majors learn and retain general biology content knowledge covered in the Biology Core (Objectives 1.1A-L and 1.2A-I) will be given each year. The pre test will be given to lower division biology majors in BIOSC 1A and the post test will be given to seniors in BIOSC 180. Students will be asked in the post test whether they have had all or just a portion of their Biology Core courses at CSU Fresno so that performance comparisons can be made between students who have had all Biology core courses at CSU Fresno vs. transfer students who have not.

2. Primary Trait Analysis of BIOSC 130 Ecology Lab Reports

This assessment activity will measure student development in data collection (Objective 2.2A), graphing (Objective 2.2B), data analysis (Objective 2.2C), interpretation of results (2.2D) and scientific writing (Objective 3.2B).

3. Primary Trait Analysis of the Microbiology Poster Session

This embedded assessment activity will implement scoring rubrics to assess elements of student application of scientific method, hypothesis testing (Objectives 2.1A-D), ability to work in a team (Objective 2.5A-B) and oral communication (Objective 3.2A). Faculty and student peers that observe poster presentations will fill in the rubric scoring.

4. Primary Trait Analysis of the Evolution Term Paper
Evolution (BIOSC 180) is considered a culminating course in the Biology Core that provides a means for students to synthesize their Biological knowledge in an evolutionary perspective. Each student in the course will write a term paper on a topic in evolutionary biology. To complete the assignment, each student must select a topic in biology, research the topic through the primary scientific literature, and synthesize and summarize the information on that topic in an evolutionary perspective. Primary trait analysis of Evolution term papers will be used to ascertain students' abilities to interpret the primary literature (Objective 2.3A) and integrate concepts (Objective 2.3B), as well as their understanding of evolution (Objectives 1.1A and 1.2A) and their scientific writing skills (Objective 3.2B).

5. Primary Trait Analysis of Core Course Test Questions
Each year, a different core course will be identified in which a specific learning objective (not addressed in other assessment activities) can be addressed in a specific essay test question planted in the course final exam. These primary traits analyses will primarily occur in lower division core courses (BIOSC 1A and 1B) to serve as formative assessment of Biological content learning (Objectives 1.1A-L and 1.2A-I).

6. Tabulation of student research activity
Although it is obvious that not all undergraduates will have the opportunity to conduct research with Biology faculty, the fact that a significant number of undergraduates are involved in this activity is a sign of a healthy and engaged Department. Each year, as part of the Department's annual report, faculty will tabulate the number of student publications, poster and oral presentations at scientific meetings, funding awards and honors. Faculty will also estimate the level of new funding made available to student researchers working in their lab. These findings should provide direct evidence that some students have mastered the process of scientific inquiry and communication.

<u>Indirect Measures of Student Learning</u>
7. Pipeline Analysis:
Pipeline analysis (conducted at the end of the review period) will follow the progress of students that become Biology majors in Fall 2005. This assessment activity is entirely dependent upon assistance from The Office of Institutional Research and Planning, and their ability to provide us with the appropriate data. We will carry out detailed analyses of student records data to answer questions such as:

- Are students taking CORE courses in sequence?

- At what points do we lose students from the major?
- Do they leave the university or transfer to other majors?
- Do we disproportionately lose minority students?
- Does the success of transfer students differ from that of continuing students?
- Can we identify predictors of success (or failure) that will allow us to provide more effective support to at-risk students?

8. Alumni Survey
Surveys will attempt to measure:

- How graduates feel about the currency, breadth and depth of their Biology education
- student satisfaction with various aspects of the Biology undergraduate program (e.g., courses, faculty, etc.).
- Relevance of degree to, and level of preparation for, current occupation
- Whether students continued with advanced degrees
- Survey will be mailed to past graduates a minimum of one year after graduation, and at the end of the Department's review cycle.

Timeline of assessment activities:

Assessment Activity	Year 1	Year 2	Year 3	Year 4	Year 5
1. Pre and Post Test	X	X	X	X	X
2. Ecology Lab Reports		X			
3. Microbiology Poster			X		
4. Evolution Term Paper				X	
5. Test Questions	X	X	X	X	X
6. Student Research	X	X	X	X	X
7. Pipeline Analysis					X
8. Alumni Survey					X