Final Report on IRAP Project:

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

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I. What was the project about and what was the issue/problem/purpose for doing it?

Current CSU-Fresno Department of Biology curriculum requires an inter-departmental course in 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, 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*".

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.

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.

A. Project Goals

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. What did the project do?

Assessing student learning generally requires more than one assessment measure (Siebert & McIntosh 2001; cited in Sundberg 2002). The primary assessment measure in this project was a pre- & post-test 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. The pre-test to assessed relevant knowledge and skills from Math 101/Psych 42, while the posttest at the end of the semester provided a relative measure of change in relevant knowledge and skills throughout the semester. This test instrument was limited to multiple choice responses to avoid the problems associated with open-ended questions.

A second project component and assessment tool was student interviews. These interviews were 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 was not difficult, as students were eager to discuss this topic. Interviews avoided the bias of involving the instructor in the process (Sundberg 2002) by hiring biology graduate students to conduct the short interviews. 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 was done via the internet.

II. What were your findings/what did you learn?

A. Pre- & Post-Test

The majority (66%) of the students taking the assessment test were 4^{th} or 5^{th} year students. Average pretest scores were slightly higher for students who had taken their statistics pre-requisite at CSU-Fresno than students who took this course elsewhere (9.34 vs. 7.71; $t\text{-test}_{1,37}$ 2.403; P=0.021). There was no discernable pattern in average pretest scores and the number of semesters since the student had taken their statistics course. Class standing (# of years at university) also did not discern average pretest

scores. It was disappointing that although 25% of the students taking the pretest had some research experience, this group did not score significantly higher than those without research experience.

Overall the pretest scores were low, with scores averaging 8.6 correct over 19 scorable items. The pretest was organized into three sections. Students averaged 66% correct on the 'definitions' section, 47% on the 'concepts' section, and just 39% for the 'interpretation' section. This last score is especially troublesome, as test items in this section had students interpreting the patterns of data presented as x-y plots, bar graphs, or a data table.

Posttest scores were significantly higher than pretest scores, but only by a small margin (9.0 vs. 10.6; t-test$_{1,44}$ =3.658; P=0.001). The pretest mean and sample size is lower than the data given above, because not all students included their student number on the posttest form.

B. Student Survey

A majority (52%) stated a preference for other statistic course options, such as a Biostatistics course. Only 17% of all interviewees did not think that other options are needed.

Students were also surveyed about their perceptions of their statistics course. Students responded to questions on a five-point scale where 1=completely disagree to 5=completely agree. Questions and results are summarized below.

Did your statistics course give you a solid foundation in:	
a) Statistical concepts	3.6
b) Experimental design	2.6
c) Data analysis & interpretation	3.1

Item 'a' averaged 0.4 lower among transfer vs. non-transfer students. Item 'b' had the opposite pattern, and averaged 0.3 higher among transfer vs. non-transfer students. Overall, these results suggest that Biology majors need more training in experimental design.

Do you think your training in biology at CSU-Fresno should include <u>additional</u> course options for the three areas in the previous questions? (Avg=3.7)

Do you think your training in biology at CSU-Fresno should include <u>alternative</u> course options for the three areas in the previous questions? (Avg=3.1)

Do you feel that you are able to take the concepts from your statistics course and apply them to the skills needed in your biology courses? (Avg=3.1)

It is interesting that ADDITIONAL is preferred over ALTERNATIVE statistics and/or experimental design courses. Students were given the opportunity to elaborate on their responses to the three items above. Overall, the comments suggest the need for a biology-based statistics course, which includes experimental design emphasis. Finally, the low score for the last item above confirms what student tell us & what we observe

C. Survey of other CSU Biology Departments

81% of CSU Biology Departments require a statistics course for all Biology majors, while all have this requirement for some Biology majors. Four Departments require two statistics and/or experimental design based courses for Biology majors. Six departments have additional electives based on statistics and/or experimental design based courses. Only seven of the 21 Biology Departments offer their own biostatistics course, which was fewer than expected. Students in ecology-based subdisciplines within the Biology major are expected to take more statistics and/or experimental design courses than students in other Biology subdisciplines.

III. How are you using the findings?

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;
d) Replacement of the Math 101 or Psych 42 requirement with a Biometry-type course in the biology curriculum.

We can also use these results to facilitate the development of teaching standards for experimental design and statistics in biology courses. Our departmental Curriculum Committee will use these findings to guide biology curriculum changes, especially those suggested in the external departmental review

IV. What problems did you encounter and how were they resolved?

There really weren't any noteworthy problems, perhaps other than that the project produced a very large amount of data that took a good deal of time to manage.

References used in project proposal:

McNeil, A.P., & C. D'Avanzo. 1996. Student-Active Science: Models of Innovation in College Science Teaching. Proceedings on the NSF sponsored conference on Inquiry approaches to Science Teaching, Hampshire College, June 1996. Saunders College Publishing.

Peterson, N.S., & J.R. Jungck. 1988. Problem-Posing, Problem-Solving, and Persuasion in Biology. Academic Computing 2(6):14-17.

Sahai, H., & M.M. Ojeda. 1999. Problems and challenges of teaching biostatistics to medical students and professionals. Medical Teacher 21(3):286-288.

Siebert, E.D., & McIntosh,W.J. 2001. College Pathways to the Science Education Standards, Arlington, VA: NSTA Press.

Sundberg, M.D. 2002. Assessing Student Learning. Cell Biology Education 1:11-15.

Zolman, J. F. 1999. Teaching Experimental Design to Biologists. Advances in Physiology Education 277: 111-118.