Provost’s Learning Innovations Grant for Faculty
Request for Full Proposal
2005-2006

Project Title: Active and Peer Learning in Introduction to Biology

Applicant(s):

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<tr>
<th>Name</th>
<th>Harvey Pough</th>
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1. Project Title and Summary: Active and Peer Learning in Introduction to Biology

OVERVIEW: We are redesigning Introduction to Biology as an active learning course that emphasizes hands-on exercises, discussion, peer learning, and real-world problems. Our goal is to present biology to freshman students as something to do rather than something to learn. Innovations are being introduced in a stepwise manner, with each advance facilitating further development of a three-year process.

This proposal requests support for revision of lecture and laboratory material by the instructor (6 weeks full time) and six students (8 weeks half time) during the summer of 2005. The instructor will rewrite the lecture portion of the course to increase active learning and implement an in-class response system and will supervise the students who will identify web resources appropriate to the laboratory projects and write sample research proposals that will be used in the class next year.

The funds requested in this proposal will be matched by funds (estimated at $40,000) from external sources, the College of Science, the Department of Biological Sciences, and Professor Pough’s start-up. The results of this pilot program will support proposals for external funding for further curriculum development and for renovation of a lecture room for active learning and a laboratory to facilitate team-based projects.

WHERE WE ARE NOW: In 2004-2005 we redesigned Introduction to Biology to engage the students in the intellectual and conceptual aspects of biology from their first day of class at RIT by presenting biology as something that they begin doing immediately, rather than merely learning what other people have done. We accomplished this by making research and the application of biological information central elements of both the lecture and laboratory portions of the course and working with the Department’s Research Scholars Program to highlight undergraduate research at RIT and elsewhere. In the laboratory the students work in teams to tackle four-week projects that are based on real-world scenarios such as analyzing the enzymatic activity of Lactaid® tablets to determine why they lose most of their effectiveness before they reach the large intestine. This approach emphasizes the relevance of basic biological information and laboratory techniques to real-world applications. The students have responded positively in surveys, and we have already seen increased participation by first-year students in research on and off campus (see section 6).

GOALS FOR THIS PROPOSAL: I will focus on increasing active learning in the lecture portion of the course. For next year we have split the lecture into two sections that will meet in a flat classroom with moveable tables. In addition, we will incorporate a student response system as part of a pilot study supported by On-line Learning. I believe that the anonymity of individual responses using this system will be particularly helpful in encouraging first-year students to participate in class activities. Student response systems are most effective when a course is built around them, and I will revamp the lectures to exploit this technology.

i) Scientific discovery is an incremental process and describing experiments and asking students to use previous information to predict the results of each new step can reveal basic principles. The responders will allow students to be actively engaged in developing an understanding of these topics.

response was strongly positive to a trial of this method in my class (Appendix 1), and I will
develop more exercises of this sort.

iii) Reaction discussions: I illustrate the interface between science and society by posing
questions that have no right or wrong answers and asking students to use their knowledge of
biology to formulate and support a position on the issue. Currently the students do these
exercises in small groups because larger interactions are not feasible. Next year—in a different
classroom and with fewer students—I will engage the entire class in the discussion, alternating
between talking with two or three other students and presenting their group’s view to the entire
class.

The undergraduates will work on two elements:

i) A computer-rich laboratory experience: An enormous quantity of useful biological
information is available on the web—molecular structures, properties of enzymes, anatomical
diagrams, photographs of organisms, and evolutionary phylogenies. The students will locate and
evaluate web sites and work with me to incorporate these resources into the laboratory exercises.

ii) Undergraduate research proposals: In fall quarter this year the students developed
criteria for evaluating non-technical articles about science, and in winter quarter they evaluated
undergraduate research publications. The logical third step in this progression is to evaluate grant
proposals but student-generated grant proposals are not public documents so they are not readily
available. Each of the six students will write two grant proposals for projects that would be
feasible for undergraduate research, and I will use these proposals in spring quarter next year.

2. Targeted learners: All first-year students majoring in Biology, Bioinformatics, Biotechnology, and Environmental Science take all three quarters of the Introduction to Biology
course. In addition, transfer students and some graduate students take one or more quarters.
Thus, this proposal targets nearly all students majoring in degree programs offered by the
Department of Biological Sciences.

3. The number of students who will be affected: Currently 100-110 students take Introduction
to Biology I, II, and III each year, and the department anticipates that the number will increase

4. Anticipated impact on teaching and learning: We will establish an effective hands-on,
lecture and laboratory course that uses a dialogue format to promote peer learning and teamwork
among first-year students and moves them rapidly into the mainstream of departmental activities.
   Expected outcomes include
   a. A greater sense of belonging, excitement about biology, discovery of an intellectual
   and professional interest and identity, and greater participation in departmental activities—in
   short, a greater sense of engagement and identification of students with the department and with
   biology as a profession.
   b. Improved problem-solving skills and greater self-confidence among first-year students
   leading to more effective assimilation into upper division courses and greater retention.
   c. Incorporation of similar elements in upper division courses. We anticipate that as
   students become comfortable with the active learning approach of Introduction to Biology,
   faculty members teaching upper division courses will adapt those methods to their own courses.

5. Impact on student success: We expect that improved problem-solving skills, greater self-
confidence, and increased identification with the department and with Biology as a profession
will promote retention. We predict that the proportion of entering Biology students who remain
at RIT from freshman to sophomore year will increase and that ultimately graduation rates for
Biology majors will increase. Potentially this effect will be most pronounced among students who are at the greatest risk of failure as predicted by admissions criteria.

6. Measurement of Impact:
Assessment of outcomes:

a. Identification of students with the department and with biology as a profession will be assessed by monitoring the number of first-year students who engage in research with departmental faculty or in off-campus co-ops and the number of first-year students who attend the department’s weekly seminars. (See Appendix 2.)

b. Improved problem-solving skills and greater self-confidence will be assessed by tracking the success of students in upper-division courses, with particular attention to students identified as at-risk on entry. I have spoken with Rohan Palma, College Liaison for the College of Science at the North Star Center, about collaborating in tracking their students.

c. Incorporation of similar elements in upper division courses will be tracked by the department chair as part of the annual review of departmental performance. (See Appendix 3.)

Report of findings and Faculty forum: See Section 7 c

7. Rationale for the project:

a. Why it is not part of regular college business:
   i) Converting a course to active learning and a student response system is a major undertaking.
   “The real successes are for the faculty who take the time to restructure the way they teach and use the system to make their lectures more interactive; these are the courses where we find students are generally positive about the experience of using the response systems and feel that it contributed to their understanding of the course materials.” (Joseph Delaney, Associate Director of Technology, Center for the Advancement of Teaching, Rutgers University, pers. comm., February 18, 2005).

   I plan to spend 50% of my time this summer on this element of the project.
   ii) Finding and evaluating web sites is time consuming and doing that will be valuable experience for undergraduates. Writing undergraduate research proposals is something only an undergraduate can do—it would be ineffective for me to try write those proposals, and this experience, too, will be valuable for the undergraduates. I plan to spend 25% of my time this summer supervising the six students who will be spending half their time on these two activities.
   iii) We are leveraging both funding and the learning opportunities for students by employing students who will be engaged in research with faculty members this summer. One of the students will be working with Professor Irene Evans and five with me. I am using start-up funds to provide support for one student and research materials for the project, and I plan to spend 25% of my time this summer supervising student research.

b. Its relevance to competencies: Engaging beginning students in science and helping them to see science as a whole

c. Transfer to other faculty: The combination of hands-on activities and the student response system is engaging. Discussion of the changes in the Intro Bio course in departmental faculty meetings has already elicited interest from other faculty, and the exercises I will develop this summer will lend themselves to workshop in campus venues such as FITL. The American Biology Teacher and the meetings of the National Association of Biology Teachers, the American Indian Science and Engineering Society, and the Society for the Advancement of Chicanos and Native American in Science and the Lilly Conference are effective for broader dissemination.
d. Experience of faculty: I have been teaching since 1969—for 25 years at Cornell, then for 10 years at Arizona State University West where I was department chair and developed a bachelor’s degree program in Life Sciences for a student body with high proportions of non-traditional, first-generation college students, and students from groups underrepresented in science. I have been at RIT since September 2004. At Cornell I received an NSF Instruction and Laboratory Improvement grant and the course I developed was recognized for “Exemplary Teaching in Biology” by the Coalition for Education in the Life Sciences. I have always included undergraduates in my research, and nearly 20 of my research papers are coauthored with undergraduates. I am the senior author of two leading biology textbooks published by Prentice Hall—*Herpetology* (3rd edition, 2004) and *Vertebrate Life* (7th edition, 2005).

e. Innovation: I believe that the combination of real-world laboratory projects and active learning incorporating response systems I have proposed is unique in biology instruction. I have been talking and corresponding by e-mail with colleagues at other institutions and many of my ideas are based on their suggestions, but I have not found any program that combines all of the elements in the way I am proposing.

8. Timetable for the project:

a) Phase 1 (Completed) — Initial redesign of Introduction to Biology. This includes the emphasis on real-world situations, the continuum between basic and applied biology, the interface between science and society, and team-based laboratory projects. These are all elements I have used before, and they have been incorporated in the course this year. In addition, we have linked first-year students to our upper division Research Scholar students by making a poster presentation for the Introduction to Biology class one of the required activities for students in the Research Scholars Program.

b) Phase 2 (Summer 2005) — Conversion to active learning with a student response system, lecture-tutorials, and development of computer-rich laboratories and undergraduate research proposals. These elements will be developed during June, July, and August to be included in the course in 2005-2006. The research proposals will be completed by the end of August and a substantial number of web sites will have been located and integrated with the labs. (Web resources are constantly changing, of course, and this element must be modified year by year.) I anticipate completing several of each of the three elements employing the response systems (lectures based on experiments, lecture-tutorials, and reaction discussions) by the end of August. (I will also have to develop new tests that reflect the increased emphasis on concepts rather than facts.) One summer is not enough to complete the conversion of a yearlong course, but I will have enough examples to see what works and to support an application for external funds to continue the process in the summer of 2006.

c) Phase 3 (2006-2008) — Renovation of the lecture room and laboratory. The timing of this stage depends on identification external funding, and I have initiated discussions with the department, the Dean of the College of Science, and the Offices of Sponsored Research and Development to identify potential sources (see Appendix 2).

Appendices

Appendix 1: A lecture-tutorial exercise for cladistics.
Appendix 2: Broader Goals and Sources of Funding.
Appendix 3: Impact on Teaching and Learning—Preliminary Results.
This is an experiment—I’m trying out a way of presenting information in class that might be more interesting and effective than a lecture. This exercise will not be graded and will not be on the exam. Please use the main idea/muddiest issue cards to tell me if you think this method is worth developing further.

CONGRATULATIONS!
You have just been promoted to Chief Medical Officer for Hong Kong.

That’s the only good news you’ll get today.

The bad news is that a new outbreak of virus has been reported. In the past 48 hours 27 people have become ill, 19 of them have already died, and 4 more are expected to die in the next few hours.

Virulent viruses like this are usually zoonotic—that is, they pass to humans from another species of animal. In Hong Kong the food markets, which sell live animals—both wild and domestic—are the most likely source of the virus and slaughtering all of the animals of the species carrying the virus usually stops the infection before it becomes an epidemic.

So that’s what you need to do, but what species should you slaughter? Will one species be enough, or must you expand the slaughter to additional species in order to eliminate the virus? The economic impact of your decision will be enormous—hundreds or thousands of animals will be killed and you will have to reimburse their owners for the loss, but if you slaughter the wrong species or omit a species that should have been slaughtered, you will either magnify the financial cost or risk allowing an epidemic to develop. You could be out of office very quickly!

Fortunately your laboratory staff is on the ball. They have already sequenced a virus isolated from three of the people who died and have prepared a table for you that compares the base sequence of the virus from the victims to base sequences that have previously been determined for viruses from several of the common food animals in the markets during previous virus outbreaks.

You decide to use the base sequence of a virus isolated from turtles in the market as your outgroup because viruses do not usually cross the species barrier from reptiles to humans. In addition, you have sequences for viruses that were previously isolated from three kinds of birds (duck, chicken, pheasant) and three kinds of mammals (dog, monkey, palm civet). With that information you can prepare a cladogram of the virus from the victims, showing which animal virus(es) it is related to, and that cladogram will tell you which species you need to slaughter.

Using the data on the reverse side of this page, determine which one or more of the species is/are the source of the virus that was isolated from the three victims. (If you need help, you can call on your lab staff to do some of the preliminary analysis of the data—they can prepare versions that you can pick up from the desk at the front of the room. You want to impress your staff, however, so your goal is to solve the problem with as little help as possible.)
APPENDIX I: EXAMPLE OF A LECTURE-TUTORIAL ACTIVITY

This activity focuses on using a method known as cladistic analysis to identify the source of infection by the SARS virus. (It is exactly the method that is used for that purpose, although this is a simplified example.)

1) Lecture overview preceding the activity (10 minutes).

2) Scenario presented to the students.

3) Data available to the students.

4) Student’s comments—Analysis and Response.
APPENDIX 2: BROADER GOALS AND SOURCES OF FUNDING

I am seeking external funding to renovate a lecture room for active learning and to renovate the laboratory to accommodate teams of three students and provide the equipment we need to train students in modern laboratory methods in biology. Within three years I hope to have completely revamped both the conceptual and physical structure of the course.

Support for equipment and building renovations:

- On-line Learning has agreed to equip the lecture room for a student response system as part of a pilot study of the effectiveness of these systems at RIT.

- The Department of Biological Sciences and the College of Science have agreed to pay for the computers and projector for the laboratory if external sources of funding are not located. On the basis of the renovations of the Physics laboratories, this is estimated to cost approximately $40,000.

- I am working with Elizabeth Perry (Senior Research Administrator, Sponsored Research) to identify sources of funding. The CCLI Program at NSF seems the most promising, and we are awaiting publication of the guidelines for 2005. We are also investigating the NSF Director’s Award for Distinguished Teaching Scholars.

- I have asked Susan Watson Moline (Director of Foundation Relations, Development Office) and Steven Schwab (Director of Corporate Relations, Development Office) to investigate the potential for funding from foundations and donations of equipment from corporations.
We have already seen an effect of the changes we have made:

**Student participation in research and departmental activities**

1) Twenty-four first-year students are engaged in research in faculty laboratories or have firm commitments to begin research this summer or next fall, and 15 have applied for summer co-ops. A search of departmental records shows no first-year students who were involved in research or co-ops in previous years.

2) In most weeks this year a third to half of the students in the seminar are from the Intro Bio course; we have no data from previous years for comparison, but the Department Head believes that this is a substantially higher proportion of first-year students than in previous years.

**Incorporation of Similar Elements into Upper Division Courses**

1) A new special topics course co-taught by Professors Buckley, Shipman, and Pough in spring quarter is being presented in an active learning format as a direct result of the success of this approach in Introduction to Biology.
Biomedical Application of Cladistics

SARS (Sudden Acute Respiratory Syndrome) virus

Virion = nucleocapsid + viral RNA without lipid membrane.

Corona virus

1. Viral glycoprotein found in the host cell membrane.
2. Virus enters cell by endocytosis.
3. Viral RNA is released.
4. Viral RNA makes viral RNA
5. Viral RNA makes more viral RNA
6. Viral RNA is translated into viral proteins
7. The virion is assembled.
8. Viral envelope glycoproteins are made on host ER and transported to the cell membrane via the Golgi apparatus.
9. New viruses are assembled by budding and are released.

Viral envelope glycoproteins bind to receptors on the host cell membrane.

Virus enters cell by endocytosis.

Viral RNA is released.

Viral RNA makes viral mRNA

Viral RNA makes more viral RNA

Viral RNA is translated into viral proteins

The virion is assembled.

Viral envelope glycoproteins are made on host ER and transported to the cell membrane via the Golgi apparatus.

New viruses are assembled by budding and are released.

Hong Kong Markets

• Virus RNA replication is prone to error (point mutations).
• So viruses evolve rapidly.
• Origin of a new pathogenic virus can be determined by analyzing base sequences.
**Selected Stages of Analysis of the Problem.**

The raw data were provided with the instructions, and students could ask for the progressive stages of analysis if they needed them. A few teams solved the problem from the raw data, most needed the second stage of analysis, and a few did not understand the process until they received the final stage.

**Raw Data Supplied with Instructions**

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<td>U</td>
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<td>A</td>
</tr>
<tr>
<td>Victim 2</td>
<td>A</td>
<td>G</td>
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<td>C</td>
<td>A</td>
</tr>
<tr>
<td>Victim 3</td>
<td>A</td>
<td>G</td>
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<td>C</td>
<td>G</td>
<td>U</td>
<td>C</td>
<td>A</td>
</tr>
</tbody>
</table>

Species have been grouped.

Final step of the analysis

Base changes mapped on a cladogram.