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A New General-Education Biology Course: An Integrated Approach

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Abstract

This introductory biology course is designed to serve both majors and non-majors, with particular attention to those students preparing to be teachers. Students are involved in collaborative and investigative work in both lecture and laboratory. Students are introduced to concepts in context through seven to fifteen scenarios based on popular issues or current research conducted at OSU. In lecture, students work collaboratively, making observations, formulating hypotheses, answering questions, and solving problems stemming from the scenarios. An extensive set of multimedia materials and demonstrations present and define the scenarios for the students. Newly developed laboratories help students solve or explain the scenarios presented in lecture. Students conduct pre-laboratory activities in a Learning Resources Center and on the WWW allowing the full use of laboratory time for designing and conducting experiments. Computers are used to collect and analyze data and produce team reports in each laboratory. Approximately 900 students will be affected each year, including 150-200 lower division K-12 education majors and a dozen upper-division science-education majors acting as group facilitators. The impact of the course is being examined via the use of test scores, attitude surveys, direct observation of students, and interviews with students and faculty.

Data is collected at the beginning, during, and at the end of each semester and about students taking subsequent courses.

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A new, general-education, biology course: An integrated approach

Project Summary

This project will develop an introductory course to serve both majors and non-majors. It will involve students in collaborative and investigative work in both lecture and laboratory. This pilot project will develop the first four of seven to fifteen scenarios that will be used to introduce concepts through popular issues or current research conducted at OSU. Students working collaboratively in lecture will make observations, formulate hypotheses, answer questions, and solve problems stemming from the scenarios. We will develop an extensive set of multimedia materials and demonstrations to help define the scenarios for students. In the accompanying laboratories, students will test hypotheses, solve problems, and answer questions posed during the lecture portion of the scenarios. We will use lecture time and instructional technology to connect lecture and lab. Students will conduct pre-lab activities in our Learning Resources Center (LRC) and on the WWW so that they will have time to design and conduct experiments during lab. Students will use computers to collect and analyze data and produce team reports in each lab. This process will allow students to discover rather than verify concepts. The LRC and WWW will also be used for students to do assignments requiring specialized software or laboratory technology. Thus experiments will no longer be confined to lab time. Approximately 900 students will be affected each semester including most lower division education majors. We will recruit upper-division and graduate-student science-education majors to enroll in *Teaching Zoology* and to act as group facilitators. We will examine the impact of this course using test scores, attitude surveys, direct observation of students, and interviews with students and faculty. We will cooperate with investigators from the *Oklahoma Teacher Education Collaborative* and the *Oklahoma Partners for the Biological Sciences* in developing and assessing teacher education components and disseminating materials regionally.

2. Problem:

The project proposed here focuses on producing a course that is "integrated" in many ways. Most importantly, it will approach the study of biology from an integrated perspective so that general principles will be applied at several levels of study (e.g. cellular, organismal, ecosystem) and so that students' investigations of biological systems or solutions to problems will require integration of materials and techniques. At a basic level, it is the result of integrating efforts on the part of three departments: Botany, Microbiology & Molecular Genetics, and Zoology. Administratively, it is the result of integrating three courses into one and students from all disciplines (majors and non-major) into the one course. It will better integrate lecture, laboratory, and out-of-class activities. It will more fully integrate technology into the course. It will integrate current faculty research interests into the course. It will integrate applied and theoretical aspects of biology into the course. It will encourage faculty to integrate current and varied pedagogy into the course.

a. History: Unlike most other Oklahoma Colleges and Universities, OSU has three introductory courses, two for non-majors (1114 and 1214) and one for majors (1304). BIOL 1114, Introductory Biology: Populations and Ecosystems, emphasizes ecology, Mendelian genetics, and evolution. BIOL 1214, Introductory Biology: Organisms, emphasizes cellular and sub-cellular structures and processes and plant and animal structures and functions. BIOL 1304, Principles of Biology, emphasizes cell structure and function, basic biochemistry and energy transformations, Mendelian and molecular genetics, ecology, and evolution. All three courses are taught in the traditional lecture/lab format. Among the three courses, sections of 120-140 students are taught by nine to eleven professors each semester (Twenty-seven faculty have taught these courses in the last five years). Teaching Assistants (TA) teach approximately 55 two-hour lab sections each semester. One faculty coordinates each course; three TAs are responsible for lab preparation.

In early 1996, the Departments of Botany, Microbiology & Molecular Genetics, and Zoology began discussions both within and among departments concerning revising the 1000-level BIOL curriculum. In Spring 1996, faculty committees in Zoology and Microbiology & Molecular Genetics independently proposed changes that served as a starting point for discussion by an interdepartmental task force. Following extensive debate, the consensus was to merge 1114, 1214, and 1304 into a single introductory course (BIOL 1114) that would be appropriate for both majors and non-majors. A new committee was appointed to develop *de novo* the course content and style. The goals are to (1) improve students' conceptual understanding and retention of material, and (2) make the course more interesting ("relevant").

b. Problems with the current system

There was broad agreement that...

1. particularly in 1304, too many topics are covered too quickly with little continuity, such that most students cannot assimilate much of the material nor make conceptual connections between the various topics. Emphasis has been on broad content coverage ("greatest number of facts per unit time") with little time spent with students actively engaged in discussion, problem solving, or any inquiry-based activity.
2. the two-hour lab period is too short to complete substantial activities. Particularly in 1304 and 1214, the lab activities are outdated, poorly equipped, and do not correspond well with the lecture.
3. the three course system creates serious course equivalence ambiguity for transfer students from other Oklahoma institutions that have a single introductory course.
4. students express typical dissatisfactions through comments and inconsistent attendance

patterns. Exam scores, particularly in 1304, are extremely low (50s-60s).

5. too much emphasis has been placed on insuring that majors become prepared for the rigor of and know all the facts and principles that are the underpinnings for upper-division courses. Both majors and non-majors need to see that science is fun and relevant; both should gain an understanding of science as a process.

The problems we face and the need to restructure introductory courses are not unique to our institution. Most recently the National Research Council (1996) developed and described the *National Science Standards* to provide clear statements concerning how science education must change if we are to produce a science-literate public. The potential impact on colleges and universities is clear - future students will want and deserve more from their science courses, and colleges must prepare now. Higher-education must also change now if we hope to put today's students on a par with future ones. How should we proceed? The problem identified by many is that while courses concentrate on concepts, terminology, and details, the most desirable outcome is students who understand the process of science (BSCS 1993; Lawson, 1992).

To create a science literate public is different from creating scientists (Bybee and McInerney, 1995), and care must be taken to design curricula for series of course that accomplish this. This logic has led to the belief that majors and non-majors should be treated differently at the introductory level (Lawson *et al*., 1990; Nastase and Scharman, 1991). Although this may appear obvious, there are data to the contrary. Sundberg and Dini (1993) compared performance and attitudes among majors and non-majors in separate classes. In their study, they found no initial difference among majors and non-majors. They found, however, that non-majors performance improved more than majors did and the non-majors attitudes appeared to improve as well. The authors concluded that this pattern results from the overload in details faced by the majors. Preliminary analyses of a survey of our majors and non-majors, showed majors and non-majors differ in performance before and after their respective courses, but this may be attributed more to ACT scores than chosen majors. However, there was no significant difference in the change of their performance and there was a significant decrease in the attitude of majors toward biology. This leads us to agree with Sundberg and Dini that separating majors and non-majors is not necessary, but changing how they are taught is. This is what we propose to do.

c. Progress to Date:

Laboratory Improvement:

In May 1993, the PI/PD received a grant from the EPA to develop a multimedia and hands-on laboratory on Wetlands for 1114. In August 1994, the PI/PD received a NSF/ILI-IP grant to furnish the 1114 laboratory and the Learning Resources Center (LRC) with multimedia workstations and digital instruments to enhance the laboratory experiences of the students. Every laboratory was modified to incorporate new exercises involving the equipment. Efforts have been made to change exercises so that students are faced with a more general question that they are to investigate, though the experiments still remain prescribed. Increasingly, we have been incorporating group work and problem solving in 1114, through the use of group responses to questions posed and answered during lab. More than 75% of the students responded favorably to this type of work when surveyed. While there has been some transfer of 1114's laboratory equipment and laboratory exercises to 1304 and 1214, the labs in these courses remain traditional with most labs consisting of verification experiments and emphasizing individual activities.

To improve students' awareness of the role mathematics plays in biology and their math skills, we are collaborating with the Mathematics Department through Project Intermath (Drs. Jim

Choike and John Wolfe, Directors). The focus of the project is to increase student involvement through the use of Interdisciplinary Lively Applications (ILAPs). ILAPs are extended discipline-specific problems, analogous to the scenarios we propose to use in our new course (see Proposed Project, below). We are assisting in developing ILAPs for their classes and providing demonstrations and data for use in sections of mathematics courses designated for biology students. The mathematicians are assisting us in developing segments for our lectures and labs that deal with quantitative topics (e.g. population growth, eutrophication rates).

Learning Resources Center:

Established in 1993, the LRC is equipped with multimedia computers, laboratory set-ups, and a library for 1114, 1214, and 1304. It is open for unscheduled student use 32 hr./wk and is staffed by faculty or TAs. The LRC was originally planned as a facility for voluntary remediation or assistance. While this service continues, the LRC is increasingly used as a facility for conducting out-of-class assignments, continuing experiments, and "extra-credit" assignments. An electronic version of the LRC was established in 1996 (www.okstate.edu/ art_sci/zoo_home/). This includes BIO-HELP, an e-mail help-line for student questions.

Multimedia-Software Development and Use:

Beginning in 1994, twenty-seven multimedia pieces for the lab and a complete set of multimedia materials for lecture were developed for 1114. More than 94% of the students responded favorably to the use of these materials. In Spring 1997, the first set of multimedia lecture materials was developed for 1304. All these materials are available for student use in the LRC, along with tutorials specifically developed for student use. WWW sites for 1114 and 1304 have been established as part of the electronic-LRC. Multimedia lecture, lab, and LRC materials are being converted to run on the WWW via *Shockwave*. Student response to WWW materials has been overwhelmingly positive. Two part-time undergraduate assistants regularly help faculty develop materials. Thirty-six honors or independent-study students have worked on multimedia projects for biology courses in the last four years.

In Fall 1997, we will be participating in the beta test of BIO 2000, a product being developed by John Wiley and Sons, Inc. (David Harris, biology editor). This product includes a text, CD-ROM, and website. This system is designed around a select set of "big ideas" and a reduced quantity of content and detail. It provides historical and experimental contexts for the these ideas and is designed to provide active learning through discovery. We will be assisting in evaluating the product for general use as well as evaluating its value for our own scenario approach (see Proposed Project, below).

There are several related efforts to insure that students have access to multimedia materials selected or produced by faculty. The Zoology Department refurbished its Instructional Computing Lab in 1996. OSU has equipped all classrooms for network and internet access and many classrooms for multimedia lecture. As part of a Student Technology Fee Program, Computer and Information Services purchased several hundred PCs for student use. The College of Arts and Sciences provides departments with mobile, multimedia-carts.

Active Learning in Lecture:

Faculty in all three departments have tried a variety of techniques to improve student involvement and performance.. Margaret Ewing has done pilot work on the use of metaphors and physical analogies. This work involved students in creative writing assignments in addition to traditional testing. Deborah Meinke has students keep journals relating classroom work to current articles in the popular press. Anne Ewing and Donald French have tested a few "scenario" discussions in which the class is presented with the description of an environment (through traditional or multimedia means) and asked to explain the observations that were made or adaptations noted. Donald French, William Henley, Roman Lanno, James Ownby, and Emily Stanley have all tried problem solving sessions, particulary in the areas of population growth and genetics. Donald French has expanded on this further by providing questions for small groups of students to answer. These took 3-10 minutes during an average of every other class period. Quiz questions varied in style and complexity. Some introduced topics by asking student to offer *a priori* explanations. Some were multiple-choice questions from previous tests in which students were to explain the correct or incorrect nature of each alternative. In some students interpreted numerical or graphical data. The first attempt at this method of conducting lecture resulted in mixed student responses and similar to those described by Orzechowski (1995). Student opinions in subsequent semesters have been extremely favorable.

3. Proposed Project:

a)Objectives:

- To create a new general-education course suitable for majors or non-majors to replace our present offering of one majors and two non-majors courses.
- To develop a curriculum for this course that emphasizes inquiry, investigation, and collaboration in both lecture and lab.
- To develop a set of seven to fifteen scenarios that involve students in exploring problems derived from popular issues or current departmental research through an approach that emphasizes evolution and integrative biology.
- To develop a set of seven to fifteen laboratories to accompany the lecture scenarios that are inquiry based and promote the discovery of principles, the process of experimentation and collaborative work in hypothesis testing and report writing.
- To develop multimedia materials for the lecture, laboratory, Learning Resources Center and WWW to support the scenarios
- To involve undergraduate and graduate students, in particular pre-service teachers, in the design of materials and facilitation of collaborative groups in lecture and lab.

b)Procedures and Methods:

Course Theme:

At present we have two general unifying themes. One is evolution. As promoted in a recent article (Storey, 1997), we plan to introduce evolution early in the course and relate all topics to the evolutionary survival of organisms. This should help improve continuity and conceptual linkage between topics and emphasize evolution as the underlying principle that is used to understand the relationships students see. Such an approach will perhaps dispel some of the misconceptions and concerns about evolution held by students. In surveys we conducted in Spring 1997, evolution was the topic most students appeared curious about. In written comments, students stated repeatedly that their high-school courses ignored or only briefly discussed the topic.

The second theme is that of integrative biology, where problems are approached from many dimensions. Consider the contradiction between how we research and how we teach. As scientists, we bring to bear a wide range of information and experience when solving biological problems. When formulating hypotheses, designing experiments, or analyzing data, we consider many factors simultaneously. We know that systems are interrelated. When teaching, however, we tend to compartmentalize topics and fail to relate prior discussions to new topics, regularly. We typically take the “textbook” approach.

When BIOL 1304 was designed, about twenty-five years ago, it was conceived as a course that would introduce students to the underlying principles that were common to zoology, botany, and microbiology, the next courses in the biology core curriculum. The students would then "know" the principles and they would not have to be repeated. However, experience has shown that the students fail to grasp principles because they lack context; they do not understand "why" they have to know these principles or how they fit into an understanding of whole organisms or ecological systems.

We plan to introduce principles in context and information as needed. We also plan to use principles repeatedly in different contexts, so that they are reinforced and so that students experience problem-solving as more than just knowing which part of the present topic to use. An example of this approach is our planned study of the surface-to-volume ratio as a "principle" to be considered in investigating systems.

Surface-to-volume considerations are rarely, if ever, discussed in introductory courses. They may be alluded to in questions of cell size considerations, but they are not formally nor quantitatively discussed. Yet a discussion among scientists from various disciplines rapidly reveals their value and use in examining gas-transfer, temperature-regulation, transpiration, absorption, water-loss, and a host of other topics. Rather than entitle a lecture in the syllabus "Surface-to-volume ratios", we envision introducing this topic in, perhaps, a lecture on adaptations to biomes (see further discussion below), where it could be introduced in terms of temperature-regulation and then applied to water loss, absorption, etc. It would then be applied in other ways at other times in the course and at other levels of organization. As the semester progresses, students should begin to apply the principle in other contexts themselves.

Lecture Format:

The belief that lecture is where content is presented and lab is where students can investigate, is not uncommon. However, research supports the proposition that lecture is also a place for investigation (Anderson, 1997; Brewer and Ebert-May, in press; Ebert-May *et al*., in press; Watson and Marshall, 1995). In the *National Science Education Standards* (National Research Council, 1996), the emphasis on active learning is clear and we are prepared to organize lectures to make this possible. Our plan is to present material in scenarios that will set the stage for collaborative work in lecture and lab. Each scenario will also prepare students for lab, not only by introducing the necessary content, but, more importantly, by allowing time to pose questions or formulate hypotheses that can be answered in lab.

We plan to select scenarios from current topics of popular interest, e.g. cancer (for a brief overview of cancer and teaching cell biology see Hatton and Hatton, 1997) or from the current research of our faculty. The latter has the added benefit of helping students make connections between what is actually done at the university and the process of science and development of theories. In each scenario, we will set the stage through a short story or description of a problem using multimedia materials to provide as much sensory experience as possible. We will also use live demonstrations performed by a graduate or undergraduate lecture assistant and, if needed, projected using the visualizer present in the classrooms. We will present material and ask students, working in groups of 3-5, to observe, compare, and offer hypotheses, to explain their observations or answer a posed question, in brief written form. Each observation period will then be followed by a short discussion/lecture period and the process will be repeated. The length of each type of period will be adjusted to fit the complexity of the scenario at hand or the general question posed. Our approach may be characterized as problem-based learning, although it does not always involve the complexity and extensive outside research promoted by others (Arambula-Greenfield, 1996).

To facilitate group interactions in lecture halls, we will investigate the use of undergraduate life-science or science-education majors. Peers may facilitate without intimidating as faculty or TAs do. We will begin testing this method in Fall 1997. These students will receive either Independent Study or Independent Research credit in Zoology, Botany, or Microbiology. Students from education will be referred by the School of Education's Office of Student Services (Dr. Marilyn Middlebrook, Director). These students will also assist with the demonstrations. We believe this will provide them with an outstanding opportunity to work in a non-traditional setting and gain experience in uses of collaborative learning, inquiry techniques, and instructional technology and the opportunity to enhance their content knowledge.

Our present courses follow a three-hour lecture/two-hour lab format. While we will be increasing the lab from two hours to three, we will not, as some have advocated (Poole & Kidder, 1996), change the overall lecture/lab structure. While arguments supporting such a change have merit, they do not outweigh the temporal, physical, and administrative constraints we face. However, because of our ability to perform demonstrations and show examples and simulations of materials in lecture using various forms of technology, we will be able to integrate lecture and lab more fully. More importantly, we will structure our lectures to set the stage for lab and to discuss lab results in lecture. Thus, we will try to develop scenarios in which we introduce a topic and set up a laboratory problem on Monday, continue with discussion and more involved or related problems on Wednesday, and discuss lab results and the principles derived from them on Friday. Let us illustrate by continuing our Surface-to-Volume example.

To set the stage for the S/V principle, we might begin with a short multimedia presentation illustrating two environments, the tundra and the desert, and asking students to describe and compare the physical environments that they see. This starting point allows for a clear constructivist approach because students have many ideas about these biomes from prior general or specific experiences. We might then ask students to compare animals that live in these regions and asking them about their adaptations. This inevitably leads to thermoregulation and size and/or shape questions and leads to questions for the lab (see below). Lecture directions that can be pursued from here include water-balance, osmosis, homeostasis, metabolism, feedback loops, renal system, protein structure, transpiration, etc..

In this project, a significant portion of our time will be spent in designing scenarios, determining directions to pursue in each, and structuring the syllabus, lectures, and scenarios to accomplish smooth transitions between lecture and lab and from topic to topic. Significant time will also be spent developing the media and lecture exercises to support each scenario.

To help students identify, organize, envision the many relationships involved in our scenarios, we plan to use concept maps. Research shows that it is a valuable organizing tool when used by either students (Arnaudin *et al.*, 1984) or faculty (Cliburn, 1990). We will use it in both ways. Faculty will provide broad concept maps as advance organizers (i.e. to provide an outline for topics). Students will be taught to create their own maps, a procedure that can be rapidly taught (Arnaudin *et al.*, 1984), and asked to do so on a voluntary or required basis. We will examine the impact of this technique on student performance (see Assessment below). A third option for the use of concept maps is to have the lecture assistant or a student produce a concept map during lecture using a whiteboard that can it have its contents projected, printed, or stored. Concept mapping may be particularly important in this course if we are to succeed, because the integrated approach presented by our scenarios does not follow the format of any textbook. While many of us promote textbooks as a resource tool to be used in a non-sequential manner, our students prefer a course that follows a text. Creative use of advance organizers and concept maps will assist students in organizing the material, seeing relationships and building connections. Hypermedia links on our WWW pages will also students in these activities.

Lab Format:

The call for investigative labs has been sounded by many and reviewed extensively (Holt *et al*., 1969; Thornton, 1972; Leonard, 1989; Gottfried *et al*. 1993). Some suggest that all labs be inquiry-based (Leonard, 1991; Sundburg and Moncada, 1994), while some suggest the need for a mixture. To genuinely engage students in the scientific process, some suggest that the laboratory for a course consist of a single experiment of the students design (Heady, 1993; Janners, 1988). Others advocate two (Stewart, 1988) or three lab periods (Crandall, 1997) for each lab topic, while others describe investigative labs completed in only one lab (Howard and Boone, 1997; Mills, 1991). All agree that labs should offer students the time and opportunity to observe, formulate hypotheses, collect, analyze, and interpret data, and design experiments. It is critical that students learn the rules of evidence so that they can formulate well written arguments to persuade others of the validity of their conclusions or to identify and refute poorly or un-substantiated claims.

Because of a desire to integrate lab and lecture over a short time-scale, we plan to construct labs that can be concluded in a single period, although some may take two. To do this we will develop specific pre-lab exercises and homework assignments that facilitate learning the basic terminology, finding the needed background materials, and becoming familiar with the procedures through simulations or practice. We will use our LRC for pre-lab activities and follow-up activities can be accomplished outside of class time using the laboratory equipment or multimedia-software and computer simulations. While we have already produced some suitable software, a truly elegant example of pre-lab simulations exists in the Biochemical Techniques course at UCSD (Jarmul, 1992). When we can, we will also make it possible to perform the pre-lab activities using the WWW. An example of a pre-lab/lab activity we are considering is a unit in which students are to test whether one can predict cell function from cell structure. One of us, Anne Ewing, has piloted a related activity in lecture using projected illustrations. The lab exercise would consist of students identifying cells using digital images, image analysis software to make measurements, and a list of cell names and their functions or locations in an organism. Pre-lab activities would guide students through identifying cell structures in photomicrographs.

To return to our surface-to-volume ratio investigation, the lab might consist of the task of predicting the relative rates at which shapes of the students design may gain or lose heat and testing this with computer-interfaced thermal probes and clay. Students would be required to provide quantitative data which we believe we can use to let students discover the actual numerical functions that are involved. The pre-lab activities might include examining thermographs and developing a protocol for selecting and measuring shapes. We will be working with members of the Mathematics Department involved in Project Intermath (Drs. Jim Choike and John Wolfe, Directors) in developing this laboratory.

A task common to all of our laboratories will be a group report. We plan to have students write and edit short reports (1-2 pgs) at the end of each lab period using the computers provided each group. The scope of the report will differ from lab to lab. If presented with a general question and set techniques, students will offer an explanation and provide supporting data. When techniques are not prescribed, then their reports might focus on describing and defending their techniques. When experiments are of the students own design, reports might more closely follow a traditional research paper or lab report. We believe this approach has at least several major benefits. It will keep students focused and on task. They know what is expected of them and that time must be used prudently. Time spent waiting for responses or reactions to take place will be used discussing strategies, results or in writing. It will strongly encourage students to come to lab prepared, i.e. with their pre-lab assignments and outside readings or experimental designs completed. We believe that this system will provide students with a sense of closure and more immediate feedback. The close proximity between lab-work and the report will help to stimulate thought and prevent distractions. Students enrolled in freshman courses are in a transition period and time management is a skill unknown to most. We believe that this technique will moderate the impact of these factors. Producing a group report in class will also encourage cooperation, promote better writing through peer-editing, and reduce group tensions caused by members who fail to participate because of poor work habits or time conflicts. We will devote considerable time to designing laboratories so that procedures or questions are not so complex and time consuming so as to make reflection and analysis impossible.

We plan to also investigate the use of labs that do span more than one period, but still allow for a report at the end of each lab and series of labs so that different aspects of a particular topic are investigated each week. For example, we presently conduct a series of labs investigating the effect of organic pollution on species diversity. We simulate stream sampling in week one and look at the effects of organic pollutants on dissolved oxygen in week two. Under our new system there will be time to write reports in each lab and to run the simulation and measure D.O. in week one, if we also eliminate other tangentially related exercises from the present lab. This will allow students to master the technology and hypothesize about factors that reduce D.O.. They can then design experiments to be completed the following week to test their hypotheses.

Integration into academic programs:

As explained above, the decision to restructure our introductory course was made by all three life-science departments, jointly. The course change has been approved by the appropriate higher-level committees and is scheduled to occur Fall 1998. We are presently meeting with affected departments (i.e. those departments that require a specific introductory life-science course) and advising units to discuss the impact of this course and to assist them in planning their transition and advising strategies. These include departments in the colleges of Agriculture, Arts and Sciences, Business, Education, Engineering, Human Environmental Sciences, and Veterinary Medicine. Thus, in the future, all students wishing to take an introductory life-science course will take this one.

Expected impact on students:

This is the first major, organized restructuring of course content, format, and teaching style in approximately twenty years. By setting a goal of creating a general-education course that will also be suitable for our majors, we hope to shift from a content-oriented emphasis to a “minds-on” approach that emphasizes process, inquiry, investigation, relevance and placing science in context. We believe that striving for scientific literacy is as important in teaching our majors as our non-majors. Between 800-1000 students will be affected each semester at the onset of the new course. We believe that the changes we will implement will facilitate academic growth in the area of science for all of our students and will result in increased enrollment in the life-sciences. We also expect to improve retention and reduce the number of our majors whose attitude toward biology becomes more negative during instruction (as was indicated by our survey).

All science-education majors and almost all other education majors will be required to enroll in this course; the remaining few usually elect to take biology. This translates to at least 150 students per semester. For these students, this course may be their primary exposure to science. Our course will be a significant departure from the traditional lecture/lab experience. It will offer a variety of experiences that will challenge the way students think about science and should serve as a model for how they might teach it. For those students who will be involved in facilitating the course it will offer an outstanding opportunity for them to apply their content knowledge and methods skills in a higher-education setting.

While relatively few of the students enrolled are racial or ethnic minorities (approximately 10%), a substantial number are women, and an increasing number are non-traditional and/or single parents. Our shift from a traditional lecture/lab format that emphasizes individual, competitive efforts to one that encourages inquiry through collaboration and group efforts is particularly well suited for these students (Posner and Markstein, 1994). A sub-project that will be supported by the requested funds is an investigation of the effect of gender on individual activities during interactions within single-gender and mixed-gender groups. While this has been shown to affect students at the K-12 level (Arambula-Greenfield, 1997; Tobin and Garrett, 1987), it is unknown what effect group composition may have at the college level. This may be an issue to be considered as institutions adopt science courses involving more collaborative work.

Outcomes affecting other institutions:

We anticipate several outcomes of value to faculty at other institutions of higher education. First is the new curriculum that we are developing and testing, which should be of interest to similar large, public, doctorate granting or research universities. In an era when professional organizations are urging us to do more in the area of collaborative and inquiry learning, which require more time, and legislatures and administrations are providing fewer resources, we may provide a valuable model for lecture and lab courses. In a similar vein, the process by which this course has been proposed, developed, implemented, and tested should also be of value to those who wish to know how it was done. If our scenario approach works, we will provide seven to fourteen lecture-lab modules. Institutions could adopt one or more complete units, one or more lecture scenarios, or one or more labs. By concentrating on developing laboratories that are self-contained units, we will serve institutions that may be looking for investigative labs but be unwilling to incorporate labs of longer duration for reasons similar to or different from ours.

Personnel:

The investigators involved in this project are the faculty charged by their departments with designing, preparing, and, implementing the new course. Each will provide expertise from his/her own area of specialization as well as that of the department they represent. Each will be primary developer of at least two of the scenarios and will be responsible for the general layout and flow of the scenario, design of advance organizers, design of problem sets or questions for lecture (work group) and homework assignments, developing student assessments, selecting reading assignments, selecting media for lecture use, producing outlines/storyboards for multimedia and WWW materials, developing laboratory exercises and LRC assignments, identifying and developing historical and research backgrounds, and outlining content. Each investigator will also serve as a liaison to his/her department and work with faculty in that department to design laboratory exercises and to highlight current research efforts of those faculty in lecture and laboratory materials.

Anne Ewing has expertise in the area of botany and represents the Department of Microbiology and Molecular Genetics. She is the coordinator for 1214 and serves as pre-medical/ health-services advisor. Margaret Ewing is a parasitologist and represents the Zoology Department. She has taught both 1114 and 1304 for many years and has received or been nominated for numerous teaching awards. She has also developed and taught several courses in the area of Women's Studies. Donald French is the coordinator for 1114 and supervises the LRC and WWW site for the Zoology Department. Before turning to the area of science education and the use of instructional technology, his research interests were the behavior and ecology of fish and crustaceans. Jeff Hadwiger is a molecular biologist representing the Department of Microbiology and molecular genetics. He has developed curricula for and taught 1214 several times. William Henley is an algal physiologist and represents the Botany Department. He has taught 1114 and 1304 numerous times. Deborah Meinke is a paleontologist who serves as an advisor to life-sciences students at OSU. She has taught 1114 and 1304 many times and represents the Botany Department. Charles Peterson is a physiological ecologist working on desert animals. He is new to OSU but has extensive experience teaching undergraduates. He represents the Zoology Department.

Creating multimedia materials and testing laboratory procedures are labor intensive. These tasks will be overseen by senior personnel but performed primarily by undergraduate students. We normally employ two students to maintain and make minor alterations to the lab, lecture, LRC, and WWW materials. These were created over a period of four years. Under the present schedule a similar amount of materials will need to be created in one year. Students will also provide assistance in preparing the laboratory manual. This is another task that must adhere to a seriously accelerated time schedule.

One graduate student will be responsible for basic data collection and observations for assessment (see below). Another graduate student will assist with developing procedures for TAs in lecture, lab, and lab prep. Because the present courses are being conducted while the new one is being developed, we foresee the need for these additional graduate students. This will also be true during the first year when the new course is conducted for the first time. Thereafter the normal number of TAs and undergraduates involved in supporting the course will be able to maintain and make normal changes to the course.

Time Table:

Time Period	Activities
Fall 1997	Conduct pre-implementation survey; develop scenarios, develop multimedia materials for lecture, pre-lab, lab, LRC; observe students in lab; present results at NABT
Spring 1998	Conduct pre-implementation survey; develop scenarios, develop multimedia materials for lecture, pre-lab, lab, LRC; observe students in lab and lecture
Summer 1998	Analyze data from surveys; develop scenarios, develop multimedia materials for lecture, pre-lab, lab, LRC; train new tas
Fall 1998	Conduct implementation survey; develop scenarios; develop multimedia materials for WWW, LRC; observe students in lab and lecture; train new TAs; present results at NABT
Spring 1999	Conduct implementation survey; modify multimedia materials; observe students in lab and lecture; revise scenarios as needed; present results at NSTA
Summer 1999	Analyze data implementation survey; revise scenarios, modify multimedia materials; develop new materials as needed; prepare manuscripts

Fall 1999	Conduct implementation survey; develop scenarios, develop multimedia materials for WWW, LRC; observe students in lab and lecture; train new TAs; present results at NABT
Spring 2000	Conduct implementation survey; modify multimedia materials; observe students in lab and lecture; revise scenarios as needed; present results at NSTA
Summer 2000	Analyze data, prepare manuscripts and final report

Facilities:

OSU has equipped several lecture halls, including those in Life Sciences West, Physical Sciences and Agriculture where our classes are typically taught, for multimedia instruction (networked multimedia PC, audio/video/data projector, visualizer, whiteboard, videodisc player, high-volume sound system). Using funds from NSF, EPA, and OSU the Zoology Department has established a thirty-seat Learning Resources Center equipped with ten networked, multimedia PCs with video-overlay/capture cards and videodisc players. The Zoology Department has an Instructional Computing Laboratory equipped with nine networked multimedia PCs with laboratory interfaces and assorted probes for physiological measurements and a projection system. Four laboratories are assigned to introductory courses. All are network ready. Two are fully equipped with one multimedia PC and videodisc player per lab-group and projection systems. These PCs also have laboratory interfaces and pH, temperature, and D.O. probes. The introductory courses also have ten video-microscopes and seventeen digital spectrophotometers with computer links (Hach DR 2000). The Zoology Department has a Graduate Student Computer Lab with presentation software, and three student workstations with video/audio digitizing boards, slide and flatbed scanners, videodisc players and authoring software (*Authorware, Director, Astound, Labview, Photoshop, Premiere*) for multimedia authoring. The PD has a similarly equipped authoring workstation. The life-science departments cooperate with the Department of Computer and Information Services, the College of Arts and Sciences Computer Support and the Chemistry Department to maintain a WWW site capable of serving interactive multimedia via *Shockwave*. The College of Arts and Sciences maintains a four year replacement cycle for computer equipment and provides the Zoology Department with budget for computer maintenance ($10,000 in AY 1996-1997). A laboratory fee is and will be collected that will provide for normal laboratory operating costs.

4. Evaluation Plan:

We plan to conduct both performance and attitude assessment before, during, and at the end of the project period. Students, teaching assistants, and faculty involved in the course will all be subjects of different forms of evaluation.

In Spring 1997, we began to assess student performance and attitude at the beginning and end of the courses. The survey instrument consisted of four parts: 1)the NABT/NSTA Biology Exam, 2) a Biology Attitude Scale (Russell and Hollander, 1975), 3) Content Interest Questions, 4) Personal Data Questions. The NABT/NSTA Biology Exam consist of eighty questions covering all areas of biology. It is designed as an exit exam for high school seniors. Its validity and reliability have been tested and are high. The Biology Attitude Scale was developed primarily to track changes in students positive and negative general attitude toward biology. It consists of fourteen questions and its reliability and validity are also high. We constructed a set of questions asking students interests in specific "theoretical" (e.g. mitosis, evolution, protein structure) and related "applied" (e.g. cancer, antibiotic resistance, sickle cell anemia) content discussed in the present courses. These questions were used to investigate differences in interests between majors and non-majors before and after exposure to the material. The validity and reliability of these questions have not yet been determined. The personal data questions requested information such as gender, current status, expected grade, intended major, ACT score, etc. All of the attitude/interest questions were measured on a five-point Likert scale. Our preliminary analysis show, little or no differences between majors and non-majors in change in performance, but a significant decrease in positive attitude for majors. ACT scores appear correlated with performance scores and need to be treated as a covariate in further and future analyses. We are partially funded to continue this assessment during Fall 1997 and Spring 1998. These will provide some of the baseline data for the study and we will continue to administer this survey at the beginning and end of each semester throughout the project period.

Test scores and final averages are readily available along with other data, such as college of enrollment, sex, etc. for several semesters for each of the professors who have taught each of our present courses and will be teaching the new course. Also available is OSU's standardized teacher/course evaluation data for each course and instructor. This consists of twenty five-point Likert-scale questions and ten open ended questions. These will provide the other baseline data for the project. Performance and attitude scores will be compared by multi-way ANOVA/ANCOVA to test the effects of the present and new courses, and to look for effects in particular sub-groups (e.g. male-female, major-non-major, traditional-nontraditional student).

We will also perform direct observations of student activities in lecture and lab. A doctoral student in Zoology, Ms. Connie Russell, is presently observing student interactions in lab groups. She is performing focal and scan sampling observations of students and measuring behaviors such as time on task, time spent manipulating equipment, time spent in discussion, etc. Her work is focusing on gender differences in single and mixed gender teams; her data will be applicable to this project at large. We will add observations of student behavior during lecture, including attendance, interactions in groups, attentiveness to particular topics or types of instructional materials, number of questions asked, etc. Behavior in lecture and lab will then be compared between present and new courses to identify changes in attendance rates, attentiveness, time on task etc. Because we will measure multiple dependent variables, we will use MANOVA for analysis.

To measure student response to the new course format and approach we will develop and validate a survey instrument consisting of no more than twenty questions measured on a Likert-scale. Questions will deal with direct comparisons of traditional/new format courses in such area as breadth of coverage, willingness to participate, insight into scientific process. The questions will be aimed at measuring students' perception and academic growth.

Our efforts to investigate student responses to lecture and laboratory methods by survey have always included a component consisting of open ended questions. Examination of the results from these indicates the need for a more detailed qualitative assessment of students opinions. We plan, therefore, to interview a set of students who have been observed throughout the courses. This has already been approved as part of Ms. Russell's experimental design. Students who are randomly selected for observation at the beginning of the semester, are consistently observed throughout the semester. A suitable subset of these students will be asked to participate in interviews. Questions will be directed at student responses to course format as in surveys, in an attempt to probe more deeply into students underlying attitudes and motivations.

Faculty perception of student performance and participation is also an important measure of course success. Faculty throughout the life-science departments are willing to comment on our present course, informally. We will take advantage of this by surveying/interviewing faculty before and after the new course is in place. The objective of these questions will be to record faculty's general impression of student response, student attendance, student performance and perceived problems with the course. We will include in our inquiries TAs and faculty teaching at the introductory level and at the upper-division level.

If this new course is truly successful, the students who complete our new course will be better prepared to handle future courses or feel more confident that they can handle decision-making with regards to science issues. Follow-up activities involving students outside the life-sciences will be difficult and are not planned at this time. However, we will identify groups of life-science students that we will track in their future courses. Because student growth under the model presented in the new course will encompass both content and process skills, we will attempt to assess these through test performance and faculty interviews or surveys. OSU's overall assessment plan calls for the development of "standard" test questions to be administered in sophomore and junior level courses that can be used for mid-level assessment. We will compare scores for students who have or have not been enrolled in our new course for differences in performance. Because such tests may not evaluate all of the process/critical thinking skills that we hope that students will develop during our course, we will also track a small cohort of students who have or have not been enrolled in our new course and interview the faculty conducting their sophomore and junior level classes. We will ask the faculty to comment on the students intellectual growth and maturity, willingness and ability to pose questions or hypotheses, quality of written work, and other measures of scientific ability not typically measured as part of the normal evaluations performed in each class. To reduce faculty bias as much as possible, the history of a student will not be made available to the instructor and, whenever possible, the instructor will be asked to comment on all students or as many as is practical beyond the actual subjects of interest.

The steering committee will be composed of the PIs who represent all three life-science departments and two-thirds of the advising staff for the life-sciences. Because of the role of all three departments in offering the introductory course and overseeing the core curriculum, all three Department heads will regularly review the course and the assessment results. The State Regents require that departments regularly develop and conduct multi-level assessment in accordance with their departmental assessment models. Because of the relationship between this project and the assessment models, the departmental assessment coordinators will also review the assessments being conducted. While we will conduct the observations, design and distribute surveys, and perform other basic data collection and analysis, OSU's Office of Assessment (Dr. Mary Jane Ward, Director) will oversee the evaluation process, assist in the analysis of data and review the interpretation of the analysis through the services of an independent investigator. The Department of Computer and Information Services provides assistance with statistical programming. All survey, interview, and other evaluation instruments will be submitted to OSU's Internal Review Board for approval. Because Ms. Russell's dissertation research will constitute part of this project, Dr. Adrienne Hyle (Department of Educational Administration and Higher Education), a member of her research committee, will be reviewing part of this work.

5. Dissemination of results:

We plan to present the interim and final results of this project at national or regional meetings of the National Association of Biology Teachers and the National Science Teachers Association. An initial presentation of our curriculum plan has been accepted as a session at the October, 1997 annual meeting of NABT. We plan to publish descriptions of the components of this project and the results of evaluations in *The American Biology Teacher*, *The Journal of College Science Teaching*, or *The Journal of Research in Science Teaching*.

The laboratory exercises will be published in a laboratory manual. Our present laboratory manuals are published by Burgess Publishing (1114), Kendall-Hunt (1304), and Wm. C. Brown (1214). We anticipate that one of these publishers will agree to handle our new manual (This is reflected in our lack of printing costs during Years 1 and 3 of the project); Burgess Publishing has already expressed a strong interest.

Because many of our pre-lab activities and LRC materials are to be made available to our students over the WWW, these materials will automatically be disseminated to any colleges and universities that may be interested in using or reviewing them. For activities, lab exercises, materials, etc. for which dissemination is prohibited due to copyright restrictions, we will place descriptions or substitute materials on the WWW. To increase awareness of this material, we will register our pages with the major WWW indexes (e.g. *Yahoo*, *Lycos*, *Alta Vista*).

We have also established and are accepting subscribers to our own listserv dedicated to discussing the introductory biology course. Although we are not yet utilizing or advertising it, we already have a dozen off-campus subscribers. We envision the listserv and WWW site as evaluation mechanisms for receiving advice on the project's concepts and progress and as a dissemination method. We will also submit information about our WWW site and the project to listservs for science educators, e.g. *NABT-L*, the listserv for the 4-year college section of NABT.

We presently employ two students who create and maintain multimedia and WWW materials. This assures that materials are continuously reviewed and regularly updated. . During the school year, response time to requests via BIO-HELP is less than 48hr. The teaching assistants working in the LRC also review and report problems with these materials

We will receive assistance in disseminating results of this project regionally through the *Oklahoma Partners in Biological Sciences* a project funded by the Howard Hughes Medical Institute and conducted by the Biochemistry Department (Dr. James Blair, Director). *OPBS* is working with two-year colleges throughout Oklahoma. The PD is the Zoology Department's liaison to the project. Materials suitable for use by K-12 students will be distributed through contacts developed as part of the *Teaching Teachers to Teach with Technology* project funded by the Dwight D. Eisenhower program. The PD is also a director of that project.

Addendum for Course and Curriculum Development Proposal DUE 9752402

1. Budget. It might better be submitted as a pilot project for two years effort at a budget level of $200,000. This would permit adequate time to show proof of concept.

The budget (see attachment) and the project scope and project time table have been modified with the objective of providing proof of concept rather than producing a final implementation and assessing long term impact of a full course. We will concentrate on collaborative exercises in lecture and lecture-lab integration for a limited scope of "scenarios". We discuss this in more detail below.

Time Period	Activities
Spring 1998	Conduct pre-implementation survey; develop scenarios, develop multimedia materials for lecture, pre-lab, lab, LRC; observe students in lab and lecture
Summer 1998	Analyze data from surveys; develop scenarios, develop lab exercises; develop multimedia materials for lecture, pre-lab, lab, LRC; train new TAs
Fall 1998	Conduct implementation survey; test scenarios and lab exercises; develop multimedia materials for WWW, LRC; observe students in lab and lecture; present results at NABT; develop additional scenarios; conduct *Teaching Zoology*
Spring 1999	Conduct implementation survey; test scenarios; modify multimedia materials; observe students in lab and lecture; revise scenarios; present results at NSTA; conduct *Teaching Zoology*; author lab manual
Summer 1999	Analyze data implementation survey; revise scenarios, revise lab exercises; modify multimedia materials; develop new materials and lab exercises as needed; prepare manuscripts.
Fall 1999	Conduct implementation survey; test revised scenarios; observe students in lab and lecture; train new TAs; conduct *Teaching Zoology*; present results at NABT; analyze data; prepare manuscripts and final report.

2. Teachers. Oklahoma State is part of a CETP. In what way will this project be reinforced by and reinforce the teacher preparation program at Oklahoma State and the efforts within the collaborative? What specific plans are there for engaging the education faculty and for utilizing some of the mentor teachers at Oklahoma State and other resources to strengthen the teacher preparation components of this proposal?

The Oklahoma Teacher Education Collaborative's (O-TEC) primary focus is the need for quality science education for pre-service educators. In the biological sciences, O-TEC is developing a course aimed at elementary education majors that follows an inquiry-based approach that dispenses with the lecture-lab dichotomy and involves small class sizes. Because of its design it cannot accommodate all of the elementary education majors in the system at present and will be unable to for some time. Even in the future, scheduling conflicts may prevent all students from taking the O-TEC course. In the meantime, the BIOL 1114 course is now the recognized general-education biology course for all majors. Furthermore, secondary science education majors are required to take the course designed for majors, i.e. BIOL 1114. O-TEC is supporting the revision of CHEM 1314, General Chemistry, the recommended course for life-science, physical science, and engineering students. Our project will complement their effort through the revision of the introductory biology course.

O-TEC is aware of our efforts and is cooperating in several ways. We will be sharing laboratory activities that are appropriate with Dr. James Blankmeyer, who is developing the biology course for O-TEC at OSU. Dr. Christina Moseley, from the School of Curriculum and Instructional Leadership, will be helping to critique our curriculum and will assist in the development of our Teaching Zoology course. She has also offered to recruit group-facilitators from the College of Education, who will enroll in our ZOOL 5030 *Teaching Zoology*. Ms. Sarah Ramsey and Dr. Martha Boedecker, Master Teachers in Residence, will help to critique our efforts relative to the needs of education majors.

BIOL 1114 involves large lecture sections and a heterogeneous mixture of majors and non-majors, but will incorporate innovative features, e.g. inquiry in lecture and lab and small group collaboration, similar to those found in the course O-TEC is developing. If feasible, O-TEC investigators will compare the academic growth of education majors involved in the two courses to examine the relative merit of each in developing higher order cognitive skills in science.

Several other education faculty are also interested in collaborating with us. Dr. Amy Leh, from the School of Educational Studies, is developing a course in *Computer-Based Instructional Development* (CIED 5153), which will be taught for the first time in Summer 1998. Students enrolled in the course will have the opportunity to choose projects developing materials for BIOL 1114. Her *Advanced Computer Applications* Course (CIED 5103) will examine materials, authoring applications, and development techniques used for BIOL 1114 and will inform students of the opportunity for involvement in this project. She has also offered to recruit group facilitators. Dr. Adrienne Hyle, from the School of Educational Studies, will be reviewing our qualitative analyses and results of our gender-related research. Dr. Tom Coombs from the School of Educational Studies, has agreed to review our quantitative analyses.

3. Use of multi-media. Please elaborate a bit more on how the multimedia modules will be used as a means for increasing laboratory competence but not replacing real laboratory or field experiences.

The primary use of multimedia will be in lecture and pre-lab activities. In lecture it will provide visual and auditory context for scenarios. For example, we are working on a module that explores photosynthesis by focusing on algae and aquatic plants encountered during a scuba dive and how they appear underwater and on the surface. The dive, absorption spectra, specimens and other data are presented through multimedia materials. An example of a pre-lab activity is a tutorial that familiarizes students with identifying and measuring cell structures in transmission electron micrographs from digital images.

In lab, multimedia materials can provide context for experiments. For example, during a lab in which students compare protein similarities among various mammals, we have a multimedia lesson that explains how to interpret antigen-antibody reactions and how samples were prepared. Multimedia software can also be used to compare simulated data to data students collect. We created a computer program that presents a virtual spectrophotometer (i.e. interactive computer display) while acquiring data from a spectrophotometer. The students use the virtual spectrophotometer to collect the absorption data from their plant pigment extracts and to "collect" absorption data for individual plant pigments that we generated and stored, previously . The virtual spectrophotometer plots all data together in real time for students to analyze.

4. Please be more specific concerning the number of modules to be developed, their subject and how they will be integrated into the course.

We anticipate that there will eventually be between seven and fifteen scenarios in the course, each running for one to two weeks. The duration of a scenario will be a balance among several factors: the complexity of a scenario, the time it takes for students to develop an understanding of the problem(s) contained, the interval before students grow weary of a particular investigation, and the number of scenarios that are needed to introduce all the concepts we wish to present. We expect to fully develop, test, and have ready for others to use at least four scenarios (lecture, multimedia materials, in-class and out-of-class activities, lab) during this pilot project. Our own needs dictate that we will have a sufficient number of scenarios to cover the entire course in various stages of development by the end of this pilot project. Of course, if the course is to remain topically current, new scenarios will always be necessary.

In terms of course content, we plan to present an overall theme of evolution, general concepts such as costs and benefits, laws of thermodynamics, form follows function, interdependence, surface-to-volume ratio, etc. and specific topics (e.g. cell structure and function, plant and animal structure and function, Mendelian and molecular genetics, metabolism, community interactions, etc.). While we will introduce specific concepts using specific scenarios, e.g. discovery of rotenone - cellular respiration, scenarios will always allow access to multiple threads (enzyme inhibition, co-evolution, exploitation of botanicals, species interaction, cardiovascular system and respiration). The scenarios we anticipate completing during this project will emerge from a list that includes such issues as: the discovery of rotenone, surviving in the desert and tundra, antibiotic resistance and emerging diseases, weight control and obesity, colon and breast cancer, diving for marine plants, the why and how of sex, barnyard waste and water quality, life on mars and the origin of life, sickle cell anemia and other genetic disorders, forensic medicine, Darwinian medicine, the ozone hole and disappearance of the amphibia, genetically engineered plants, and substance abuse.

Scenarios will provide context and framework for each topic. The course syllabus will introduce the scenarios along with the major biological concept(s) that will be introduced in each. During lecture, students will construct explanations of the concepts introduced in the scenario and develop hypotheses or questions to be tested in lab. We will guide the students toward appropriate questions for lab. Over several class periods, we will discuss various concepts related to the scenario and apply the results from labs. Because scenarios will integrate various concepts, we will use organizational aids such as concept maps, hyper-linked WWW pages, or even simple lists of related concepts and information to identify items introduced earlier or preview materials to be discussed in detail later.

5. Please indicate how the material once developed will be disseminated. Do you have Beta test sites or an indication of other institutions interested in working with you? Please include letters of interest.

We plan to disseminate information about and the materials from this project in several ways: traditional presentations and papers, electronic dissemination, and direct contact. We have already presented our plans at the October meeting of the National Association of Biology Teachers and plan to present our results at future meetings of NABT and the National Science Teachers Association. We will make our materials (syllabi, lecture materials, pre-lab exercises, lab exercises supplements, etc.) available on our website (www.okstate.edu/artsci/zoo_home) and will post notices on listservs such as our own and the one run by NABT. Both the *Oklahoma Partners for Biological Sciences* and the *Oklahoma Teacher Education Collaborative* will help to disseminate materials to their member institutions and develop Beta test sites. Dr. Mark Bergland, University of Wisconsin - Fall River, is interested in critiquing our materials, assisting in disseminating material, and sharing the materials his project has developed. Drs. Sharolyn Belzer
and Donald Streubel are also interested in critiquing and, if possible, testing our materials at Idaho State University.

B. Revised Budget Justification

PERSONNEL: Details of the personnel responsibilities are included in the Project Narrative. In general, the PIs will be responsible for course and content development, designing scenarios and instructional media, and designing experiments. Each of the PIs has expertise in different subject areas and collectively represent the three life-sciences departments involved in this project. The Graduate student will assist with the assessment activities (student observations, survey distribution) with preparing materials the laboratory and with developing a guidebook for TAs. Undergraduates will assist in multimedia and CAI development and testing of laboratory procedures. In general these students will have high technical skills. The undergraduates will work approximately 15hr/week during the year and full time in the summer. All of these activities are labor intensive. A research associate from the Office of Assessment will oversee the evaluation of the project. Because we are concentrating on a reduced set of scenarios during this pilot period, the revised budget reflects a reduced need for graduate and undergraduate assistance. When the bulk of the materials are developed, the normal complement of TAs and undergraduate assistants involved in supporting the introductory course will be able to provide sufficient assistance. A Grant for Instructional Improvement from OSU will provide summer salary for the PD and Graduate Assistant during year 1.

SOFTWARE: Software upgrades will be funded by a Grant for Instructional Improvement from OSU

TRAVEL: Travel costs will subsidize one trip to the National Association of Biology Teachers meeting and one to the National Association of Science Teachers meeting to present papers each year.

CD-ROMS/ DATA CARTRIDGES: These costs will be assumed by OSU.

PUBLICATION COSTS: Costs incurred for production of lab manuals will be provided by other sources. Burgess Publishing and W.C. Brown have both offered to produce “draft versions” of the lab manuals.