Investigating Life NSF Year 2 Annual Report

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Activities and Findings

1. Major research and education activities

What have been your major research and education activities (experiments, observations, simulations, presentations, etc.)?

Overview of the project

Biology: Exploring Life is a new kind of integrated high school biology program for 9th and 10th grade teachers and students. *Exploring Life* will consist of a short textbook, a set of exploratory lab and field activities, and an extensive World Wide Web site that will provide an interactive learning environment for all students and a source of daily support and collaboration for teachers. The integration of these components should enable all students to explore life actively instead of limiting them to passive exposure to content. This biology program should be adaptable to the unique needs of teachers and students by providing a broad range of resources that can be selectively integrated into the curriculum.

The main goal of the funded project is to guide the development of the *Exploring Life* biology program designed to improve high school biology students' understanding of fundamental biological concepts. The students' self-confidence and skill in scientific reasoning and inquiry and their ability to apply biological knowledge and the methods of science to important social issues should also be enhanced, consistent with the National Science Education Standards.

The aim of the formative evaluation is to assess the materials in terms of their ease of use, pedagogy, program performance, and clarity and depth of content. The four major formative evaluation issues are,

1. Do the materials address the important goals of biological science teaching and learning?
2. Are inquiry and activity the basis of the learning experiences?
3. Are the topics of the unit and the modes of instruction developmentally appropriate?
4. How are teachers implementing the materials?

These evaluation issues were addressed in a series of data-collection measures. These included the AIBS/Packard review instrument with additional items from the AAAS criteria for evaluating the quality of instructional support instrument, the *Web-based Inquiry (WBI) for Learning Science* instrument, feedback questionnaires, focus group questions, field observations, post implementation surveys, student attitudes surveys, teacher and student interviews with open-ended questions, and pre- and posttest content knowledge quizzes.

Forty-eight high school biology teachers selected from a stratified sample of thirteen distinct geographical regions participated in the evaluation of the *Exploring Life* materials during the second year of the grant implementation period. The participants reviewed the *Exploring Life* Web-based and text prototype materials at one of three evaluation workshops. Workshops were held in June 2001, August 2001, and November 2001. Feedback and recommendations resulting from the evaluation workshops were reported back to the development team.

During the second year of the grant implementation period, sixty-one participants pilot tested *Exploring Life* materials with 3673 students. The evaluation team conducted eight field observations. Each report has been discussed with the development team and the recommendations made by the evaluation team have been acted upon. Throughout the second year of the project, close, almost daily contact occurred among the evaluation team, the development team, and the teacher pilot testers.

Summary of Major Accomplishments

Data from year 2 pilot testing supported the following conclusions:

- The *Exploring Life* program is adaptable to the unique needs of teachers and students and provides a broad range of resources that can be selectively integrated into the curriculum.
- *Exploring Life* contains modes of instruction that are developmentally appropriate for a wide range of learners.
- The *Exploring Life* instructional materials are interesting, engaging and effective for both female and male students, as well as under-represented and under-served students (e.g., ethnic, urban, rural, with disabilities).
- Features of the Web-based instruction assisted student learning. These included receiving immediate feedback to responses, being able to perform activities over and over again, and having user control of the interactivities.
- The "virtual demo labs" and the hands-on classroom laboratories helped students understand the biology concepts.
- The design of the Web-based materials supports the 4E learning cycle model. A variety of inquiry-based activities are provided to accommodate diverse learning styles.
- Pre- and posttest results of biology content knowledge reveal that students are learning the biology concepts and content using the *Exploring Life* materials.
- The interactivities and graphics on the Website are helping lower level students and low-level readers understand the main concepts.
- *Exploring Life* is a flexible program that allows biology teachers to pick and choose from a variety of types of activities to use with their students.
- As a result of using the *Exploring Life* materials, some teachers "see potential for higher implementation of technology integration" in the biology classroom.

- The *Exploring Life* listserv continued to serve as a community support network and an ongoing discussion forum among the developers, the teachers, and the evaluation team. The listserv was used to share ideas, request information on biology content, and for soliciting assistance to solve technology implementation issues. The listserv was also used to elicit ideas and feedback from the teachers to assist with development decisions.

2. Major Findings from NSF activities
What are your major findings from the activities identified above?

Description of Project Activities for the Year

Three evaluation workshops were conducted during the second year. Calls for participation were posted on national and state educational listservs and bulletin boards. Biology teachers that were interested in participating in the *Exploring Life* evaluation completed a 44-item survey. The survey allowed us to select participants with varied demographics and background characteristics, including geographical area, socio-economic level of the school, years using the Internet for teacher planning/preparation, perceived preparation to use the computer and Internet in classroom activities, training to integrate instructional technologies into curricula, number of computers in the classroom and school, student-to-computer ratio, and extent of technology use in the classroom.

Table 1 lists *Exploring Life* materials that were evaluated and the data-collection instruments that were used during each workshop.

Table 1. Evaluation Workshop Activities in Year 2

Workshop	Materials Evaluated	Data Collection
NECC June, 2001 (15 participants)	· Prototype chapters	· Evaluator observations: Usability · AIBS/Packard review instrument · Focus groups · **Small group open-ended questions**
Lehigh University August, 2001 (28 participants and 1 preservice teacher)	· Prototype chapters · Conducted PhotoFinish laboratory	· Evaluator observations: Usability · AIBS/Packard review instrument · Focus groups · **Web-based inquiry instrument**
NABT November, 2001 (5 participants)	· Prototype chapters · Conducted three new laboratories	· Evaluator observations: Usability · AIBS/Packard review instrument · Focus groups

The evaluation team conducted eight classroom field observations during the school year. The findings of the classroom field observations and each evaluation workshop were discussed with the development team. Members of both teams met four times during the year. Recommendations resulted in the modification of Website design features for the development of new interactivities. Many of our workshop participants pilot tested the *Exploring Life* materials in their classrooms during the 2001-02 school year. Students completed pre- and posttests for biology content knowledge and concepts before and after using the chapter materials, and also completed an attitude survey after using the materials. After students completed a chapter, each teacher submitted a post-

implementation survey. Follow-up phone interviews were conducted with selected teacher participants. In addition, participants reviewed new laboratories during the academic school year. Currently, the development team is producing additional text chapters, laboratories, and Web components.

Evidence of the Effectiveness of the Efforts

Notable product improvements have been made in the design of the instructional and support materials during the second year of the project. Table 2 summarizes the changes made to the *Exploring Life* program as a result of the NSF evaluation feedback. The resulting modifications were used in the development of additional materials for succeeding chapters.

This section describes the evidence of the effectiveness of the *Exploring Life* materials based on the data collected. Additional details are discussed in the *Results of Formative Evaluation* section below.

Participants using the new interface in the evaluation workshops did not experience navigational difficulties as in the previous workshops with the earlier prototype chapters. Furthermore, students using the new interface did not have problems navigating within the new Website. The redesign of the *Exploring Life* Website interface appears to have solved the navigation problems that occurred with the prototype.

Student access to the *Exploring Life* materials is dependent on a school's computer network system configuration. In some schools, students log on to their computers and are able to enter a specific *Concept* in less than a minute. In other schools, it may take up to six minutes to log into a computer and access the Website.

Individual teachers selectively chose from a variety of Web-based instructional materials to meet their curricular objectives and accommodate the diverse learning needs of their students.

The Web-based materials are appropriately designed to assist learners with understanding biology content and concepts.

Implementation issues experienced by Year 2 pilot testers suggest the need for product support and services beyond the delivery of high quality content.

Table 2: *Exploring Life* Product Improvements as a Result of NSF Formative Evaluation.

Instance Prior to Feedback	Evaluation Feedback	Resulting Product Change
Chapter 7, Lab 7.1 ***Investigating Chemical Energy Stored in Food*** involved burning a peanut to determine its calorie content.	Pilot testers pointed out the high incidence of peanut allergies among high school students and suggested adding caution notes to the Teacher Resource material along with alternative ideas for classrooms with peanut-allergic students.	The developers revised the Teacher Resource material accordingly. The Teacher Resource for this lab now includes a section called ***Health Concerns***.
Online Activities and WebQuests had desired length goals with estimated time periods to complete.	Pilot testers expressed concern that some of the activities were too long. WebQuests designed for 25-30 minute execution were taking close to an hour to complete and some Online Activities were overly long and complex. Teachers wanted to be sure that students could accomplish an activity within a given class period and that the amount of time allocated per chapter was appropriate to the importance of the chapter.	Developers revised the estimate time required to complete each activity type. Specific goals were set (e.g., no more than five external links per WebQuest), complexity of the activity was re-scaled appropriately for the importance of the concept, and great care was given to streamline the activities.
The ***Exploring Life*** Website includes online self-assessments within each concept's activity as well as server-scored assessments at the end of each chapter.	Pilot testers constructed their own worksheets because they felt the need to track student progress through the activities. They expressed a desire for some type of written accountability from the student beyond the assessment tools already available.	Based on specific suggestions from the pilot teachers, the developers devised a print supplement (***Learning Log***) that consists of one worksheet for each concept in the book/Web. Teachers can assign these worksheets and collect them after class.
Building highly interactive multimedia may result in slow download time depending on the user's hardware and Internet connection speed.	Teachers complained of slow download time, even on computers with broadband access including cable or T1 connections.	The developers devised a plan to retain the richness of the media while reducing download times. They (1) used smaller sized assets, (2) began to use multiscreen templates (which eliminated load time lags within activities), and (3) devised a loading scheme to load all directions first. This allows the student to read while the rest of the activity loads and provides the additional benefit that the directions get read before the student engages in an online activity.
Lab 8.1 Photo Finish	Teachers had difficulty getting results with the lab. Leaves from different parts of the U.S. were used (whatever was available locally) and the pilot testers could not get their leaf disks to sink in the solution.	An alteration was made to the procedures section to add detergent to the solution. This addition fixed the problem – the leaf disks sunk. Additionally, the lab team added a note in the Teacher Resource material to suggest that, as an option, a teacher could sink the entire class's disks in beakers instead of individual syringes for individual students.
Students have diverse learning styles.	Not all pilot testing students liked everything in the program.	Suggestions to teachers in the support materials were added on ways to implement the program to accommodate diverse learning styles.
Teaching environments vary widely.	Field observations noted tremendous variability in the teaching environment (school facility, classroom arrangement, available hardware, class size) and the resultant effects on teachers' ability to use	The development team has worked hard to maintain the flexibility of the program. Teachers can selectively choose from among a chapter's resources to easily adapt the program

	the program.	to their particular teaching environment.
Pilot testing with Web-based materials is a difficult undertaking requiring the procurement of hardware and software along with careful planning. Of the 87 pilot testing teachers, 29.9% dropped out of the program, not completing their pilots.	The evaluation team analyzed the problems cited by "dropout" teachers and concluded that the teachers required additional advice on how to use computers flexibly, in a wide variety of ways and settings.	As a result, more information was given in the initial orientation meeting on the various possible configurations and uses of the computer (beyond just using a computer lab). This information was further developed into Chapter Planning Guides that will appear in the Teacher's Edition of the textbook. Plans are in discussion for teacher training and mentoring scenarios.
The computer is used on a regular basis with this program.	Teachers were having hardware and software problems. The evaluation team analyzed the problems reported by the participants and found that all teachers were experiencing similar technical problems. They concluded this was inevitable given today's computing equipment and the technical support structure of many schools.	New information was added to the teacher support materials. An ***EL Community Website*** (www.usingexploringlife.com) was developed and contains an area designed to help teachers solve basic implementation and technical issues. These include: (1) Suggested ways to connect with the technical support staff at each school. (2) Ideas and suggestions to include the school technical support staff as stakeholders in the adoption process. (3) Cultivating a network of systems people to serve in an advisory capacity for new users. Alerted Prentice Hall technical support and sales people to most common issues and encouraged them to bring the school's systems people into the adoption process.
Teachers were having problems determining if they had appropriate hardware and software configurations and identifying technical support staff at their own schools. Many teachers found that their "technical support staff" was not actually staffed with technologically sophisticated technicians.	The quality of school-based technical support systems organization, management, and skill level was compared with a sub-sample of schools.	The results showed that some teachers are better supported than others. Teacher support and training is necessary for all teachers but particularly for those poorly supported in their own institutions. Currently, the Prentice Hall technical support is receiving training on the range of hardware and software issues that arose during the pilot tests. Teacher training and ongoing professional development opportunities will be considered.
The Digital Divide.	Field observations revealed there are schools that acquired computers with funds from granting agencies.	The ***EL Community Website*** includes a list of granting agencies and philanthropy organizations.
Addressing student misconceptions.	Feedback from the AIBS/Packard and ***AAAS Criteria for Instructional Support*** instruments noted that the materials did not address common misconceptions of students.	The Chapter Planning Guide for each chapter in the Teacher's Edition contains a section called "Addressing Naïve Conceptions."

Assessments.	Feedback from the AIBS/Packard and ***AAAS Criteria for Instructional Support*** instruments noted that the materials did not contain a wide range of assessments that could be used for diagnostic and formative purposes.	The Chapter Planning Guide for each chapter in the Teacher's Edition contains a section called "Assessment and Remediation" that provides alternative assessments for teachers to use.

The Results of Formative Evaluation

Evaluation Design

Throughout the development of *Exploring Life*, we have employed a user-centered design strategy that focuses simultaneously on interface issues, students and teachers' subjective experiences in using Web-based interactivities, and student learning outcomes. A concurrent integrative formative evaluation process was used to evaluate the *Exploring Life* program. The aim of the formative evaluation is to assess the materials in terms of their ease of use, pedagogy, program performance, and clarity and depth of content. Our mixed method approach combines experimental methods and qualitative approaches. An illuminative approach was used to discover how the program works by observing and measuring the teaching and learning process. Our aim was to discover which factors and issues are important for biology teachers in successfully implementing *Exploring Life* with their students and to convey this information to the developers for their use in helping the program achieve its intended objectives. We proceeded through iterative cycles of design and evaluation.

A battery of methods and instruments was used in the Year 2 evaluation. These included:

1. *Content knowledge assessments*. The assessments were constructed by the *Exploring Life* developers with considerable input from members of the evaluation team. The quizzes were given to 9th and 10th grade biology students before and after using an *Exploring Life* chapter. Each question usually corresponds to a distinct learning objective. For consistent marking, these quizzes are multiple choice.
2. *AIBS/Packard review instrument*. This evaluation instrument examines how well the instructional materials are likely to help students learn the important ideas and skills in the widely accepted *National Science Education Standards* and in the *Benchmarks for Science Literacy*. Biology teacher participants completed this in teams during each evaluation workshop.
3. *Web-based Inquiry (WBI) for Learning Science instrument*. This evaluation instrument classifies science WBIs on the World Wide Web along a continuum from learner-directed to materials-directed across the five essential features of inquiry as described in *Inquiry and the National Science Education Standards*.
4. *Usability analysis*. We focused on determining whether or not the interfaces were consistent and easy to use (user evaluation) and determining whether or not the program performed as specified (functional evaluation).
    1. *Evaluation workshops*. Biology teachers were given Web-based and text materials to review prior to an evaluation workshop. In each evaluation workshop, biology teachers were observed as they worked through the Web-based materials for one and a half hours. Each biology teacher participated in a focus group session after he or she worked through the materials.
    2. *Site-based field observations*. Evaluation team members visited a sample of classrooms as observers, gathering open-ended observations. Eight classrooms of students were observed using the *Exploring Life* materials.

5. *Implementation measures.* Biology teacher participants completed a post-implementation survey consisting of open-ended questions and Likert-scale items. The instrument was designed to address two of our main formative evaluation questions:
    1. Are the topics of the unit and the modes of instruction developmentally appropriate?
    2. How are teachers implementing the materials?
6. *Attitude measures.* Student participants completed an attitude survey consisting of Likert-scale items. The instrument was designed to determine which features of the *Exploring Life* materials assisted student learning.
7. *Interviews with students.* Semi-structured interviews with a sample of students were conducted to initiate discussion about their perception of learning with *Exploring Life*. The students' comments acted as prompts for each other.
8. *Lab test.* A sample of students were administered a design experiment task. A rubric was used to measure the proficiency of students in performing the task.
9. *Interviews with teachers*. Semi-structured phone interviews were conducted with arbitrarily selected *Exploring Life* teacher participants that had completed at least two chapters of the materials with their students. The intent of the phone interviews was to acquire additional information that was not reported on the survey responses.
10. *Computer experience questionnaire*. This instrument asks about past and current computer and Internet training, usage, skills, and confidence about computers and Web-based learning.

AIBS/Packard review instrument

Table 3 displays the results of the AIBS/Packard review instrument. The main findings on the effectiveness of the *Exploring Life* program were based on teacher-participant team responses (n=48) to the AIBS/Packard review instrument that was modified to include additional instructional support items from the AAAS Project 2061 biology textbook evaluation instrument. Findings include:

Strengths:

- The materials do a good job of providing opportunities for students to do scientific inquiry and understand scientific inquiry. Activities on the Website provide learners with opportunities to: identify questions and concepts about objects, organisms and events in the environment that guide investigations; design and conduct scientific investigations; use technology and mathematics to improve investigations and communications; formulate scientific explanations using evidence; and communicate a scientific argument.
- The instructional materials provide opportunities for students to understand local as well as global phenomena and challenges that occur on scales that vary from quite short (aerobic exercise effects) to very long (potential result of global changes).

- Some of the instructional materials provide students with the opportunity to develop understandings of science as a human endeavor, the nature of scientific knowledge and historical perspectives.
- The *Exploring Life* materials contain many activities that correspond to the National Science Educations Standards' definition of active learning: *Learning biology is something students do, not something that is done to them. In learning science, students describe objects and events, ask questions, acquire knowledge, construct explanations of natural phenomena, test those explanations in many ways, and communicate their ideas with others* (National Research Council, 1996, p. 20).
- The *Exploring Life* program engages students in activities that help them to connect the biological sciences to current issues and events at the personal, community and global levels.
- The instructional materials are likely to be interesting, engaging and effective for all populations of students (e.g., gender, ethnicity, disability, rural, urban).
- The instructional materials provide students some opportunities to develop deep understanding of the biological concepts through the use of thought-provoking questions embedded within the instructional materials and by providing learners with opportunities to monitor their understanding with immediate feedback functions on the Website. The materials employ a logical progression for developing conceptual understanding of the biology content in the reviewed chapters. In some areas of the program, the materials revisit, summarize and provide closure for the intended learning concepts.
- The instructional materials include traditional classroom-based assessments and scoring guides that can be used to gather summative student achievement and performance data on important biological concepts and abilities. Immediate feedback opportunities in the Web-based materials provide learners with formative assessment opportunities.
- The existing format for the teacher support material in the *Teacher Resources section* appears easy to follow. The directions for implementing activities are clear.
- Overall, the materials for the students are well-written, age-appropriate and compelling in content. For the most part, visuals and Web-based interactivities are used appropriately to promote learning. The materials involve students in a logical or strategic sequence of activities as opposed to just a collection of activities.
- The *Teacher Resources* section contains background information, time frames, suggested uses for concepts and implementation suggestions for using the materials in different technology equipped classrooms.
- Field observations show that the *Exploring Life* instructional materials are interesting, engaging and effective for both female and male students as well as under-represented and under-served students (e.g., ethnic, urban, rural, with disabilities).

Weaknesses:

- The materials do not provide learners with opportunities to develop the abilities of technological design as described in the *National Science Education Standards*. It was noted that this is a more difficult task to accomplish in a biology curriculum than in other science disciplines.
- The view that all scientific ideas are subject to change was not addressed in the reviewed materials. Only present-day knowledge was presented.
- Performance standards associated with the assessments are not clear and explicit. There are few assessments included that can be used for diagnostic purposes. Ways to use assessment data to modify instruction are not addressed.
- There is a lack of sufficient background information on common student misconceptions regarding each chapter topic.

The results from the above section will be used to help guide further design and development of teacher support materials.

Table 3. Results of the *Exploring Life* Materials Review Instrument. [Rating scale: Exemplary /Well Addressed (5), Excellent (4), Adequate/Somewhat Addressed (3) Inadequate (2), Poor (1), Not addressed (0)]

Criteria for evaluating the quality of instructional support		Summer 2001 (n=20 groups)		November 2001 (n=2 groups)	
		Mean	sd	Mean	sd
OCS-1	Science as Inquiry	4.03	0.64	4.00	0.00
OCS-2	Science and Technology	3.25	1.38	3.50	2.12
OCS-3	Science in Personal and Social Perspective	3.68	0.85	4.00	1.41
OCS-4	History and Nature of Science	3.20	1.08	3.00	0.00
POC-1	Active Learning	4.23	0.57	5.00	0.00
POC-2	Depth of Understanding	3.53	1.07	4.00	0.00
POC-3	Assessment	3.53	0.90	3.50	0.71
POC-4	Presentation and Format for Teachers	3.83	1.15	2.50	3.54
POC-5	Presentation and Format for Students	4.16	0.97	5.00	0.00
POC-6	Implementation and System Support	3.32	1.12	1.50	2.12
POC-7	Equity Issues	3.97	0.84	3.50	0.71

Web-based Inquiry (WBI) for Learning Science Instrument

Eight *Exploring Life* activities developed for the three prototype chapters qualified as science WBIs. The placement of each activity on the WBI instrument is provided in Appendix A, available online at **http://www.lehigh.edu/~inexlife/nsfreport2/a.pdf**. Each WBI was reviewed by either three or four teams of teachers. Each team examined two or three WBIs using a multi-pass unanimous consensus approach (iterative analysis until 100% agreement among the teachers on the classification of each WBI is reached). As a second validation, each team justified their placements to a science educator member of the evaluation team.

The prototype materials contain a variety of inquiry-based Web activities. The Webquests, laboratories and Explore! activity are materials that contain essential features of inquiry and would actively involve students in learning biology.

Webquests. Webquests can be described as materials-directed partial inquiries that tend to be very specific about what learners should do and often lead the learner towards expected conclusions or explanations. This is an appropriate design, given that the instructional goal is to have the learner complete the activity within one classroom period.

Laboratories. The laboratories provide learners with a question to investigate, protocols for data collection and opportunities to think about experimental design. A series of questions direct learners to formulate conclusions. One of the four laboratories reviewed was a verification lab. One of the four laboratories had learners evaluate their conclusions/explanations in light of alternative explanations/conclusions. The guided inquiry lab had learners communicate and justify their proposed conclusions/explanations. No laboratories were classified as full inquiries; that is, none contained all five essential features.

Explore! The Explore! activities are designed to enable students to apply and extend the concepts through active participation. The reviewed WBI Explore! is an information-seeking activity that uses existing online Web resources to investigate a research question and was classified as a full inquiry containing all five essential features of inquiry.

The WBI activities support the 4E learning cycle model using inquiry for learning science. The Webquests used in the "engage" phase involve learners in a material-centered inquiry activity. These activities are used at the beginning of the unit and require no formal knowledge of the topic. In the *"explore"* phase, features of inquiry are used to:

1. reinforce understanding of concepts in verification-type labs,
2. apply concepts in Explore! activities, and
3. practice processes of science in the guided inquiry and other non-verification type laboratories.

A variety of inquiry-based activities are provided to accommodate diverse learning styles. Materials-directed activities are appropriate for lower-level learners and students with IEPs that require much guidance and structure in their learning activities. The guided inquiry lab provides a more learner-directed experience that is appropriate for students to become familiar with experimental design.

The materials align well to the anticipated product that was stated in the NSF proposal. The findings of the WBI analysis strongly support that the following goals of the *Exploring Life* program are being met:

1. The materials address the important goals of biological science teaching and learning.

2. Inquiry and activity are the basis of the learning experiences.
3. The modes of instruction are developmentally appropriate.

The WBI results will be used to help guide further design and development of WBI materials. As additional inquiry-based activities are developed, opportunities for learners to evaluate their explanations/conclusions in light of alternative explanations/conclusions will be included. In addition, opportunities to communicate and justify proposed explanations and conclusions are to be incorporated in select WBIs.

Content Knowledge Assessments

Data interpretation

Individual questions were designed to address biological content acquisition, concept application, and naive science conceptions. Percentage scores were calculated for each individual question on the pre- and post- content assessment. Any percentage gain in a question with a mean in the lower third percentile ranking (0-33%) is considered good. A double-digit percentage gain (at least 10%) in a question with a mean in the middle third percentile ranking (34-66%) is considered good. Any percentage gain in a question with a mean in the upper third percentile ranking (67-99%) is considered good.

A paired *t*-test was used to identify significant differences between the overall pre- and posttest scores at an alpha level of .05. The hypothesis we tested: There is no significant difference between pretest and posttest mean scores.

Results

The scores of the pretests and posttests of the three pilot chapters show that students' content knowledge increased significantly. (See Tables 4, 5, and 6).

Table 4. Analysis of Content Assessment Item Scores from Chapter 7 - *The Working Cell: Energy from Food* (n=2278)

Question number	Ch.7 Pretest % correct	Ch.7 Posttest % correct	% change
1	48.9	59.5	10.6
2	43.4	61.1	17.7
3	48.1	68.6	20.5
4	50.6	50.0	-.06
5	63.3	55.1	-8.2
6	66.4	52.0	-14.4
7	34.5	51.4	16.9
8	35.0	47.0	12.0
9	17.8	41.9	24.1
10	27.3	51.4	24.1
11	54.9	50.2	-4.7
12	31.9	53.9	22.0
MEAN	**5.59**	**8.03**	**43.6**
t-TEST	**t=43.384**	**df=2277**	**p<.001**

Table 5. Analysis of Content Assessment Item Scores from Chapter 8 - *The Working Cell: Energy from Sunlight.* (n=2377)

Question number	Pretest % correct	Posttest % correct	% change
1	47.6	58.8	11.2
2	36.8	56.3	19.5
3	51.3	67.0	15.7
4	38.0	57.4	19.4
5	38.0	53.2	15.2
6	21.1	35.7	14.6
7	34.8	55.8	21.0
8	18.3	46.5	28.2
9	16.2	37.9	21.7
10	21.2	25.8	4.6
11	34.5	41.8	7.3
12	39.3	45.9	6.6
13	29.1	49.5	20.4
14	27.2	32.7	5.5
15	20.6	43.1	22.5
16	19.0	23.6	4.6
17	28.2	39.0	10.8
MEAN	**5.54**	**8.52**	**53.8**
***t*-TEST**	**t=43.689**	**df=2376**	**p<.001**

Table 6. Analysis of Content Assessment Item Scores from Chapter 36- *The Biosphere.* (n=1281)

Question number	Pretest % correct	Posttest % correct	% change
1	66.4	75.9	9.5
2	46.6	59.5	12.9
3	43.5	58.7	15.2
4	50.3	50.5	0.2
5	29.5	49.4	19.9
6	14.1	26.3	12.2
7	8.0	21.4	13.4
8	59.2	63.5	4.3
9	21.4	26.3	4.9
10	21.8	45.4	23.6
11	31.3	38.3	7.0
12	19.7	32.9	13.2
13	34.0	42.4	8.4
14	19.4	43.3	23.9
15	20.7	48.3	27.6
MEAN	**5.45**	**8.17**	**49.9**
***t*-TEST**	**t=29.053**	**df=1280**	**p<.001**

- Each Chapter 8 and 36 item with negative percent changes from year one had positive percent changes in year 2.

- The score of question 6 from Chapter 7 decreased on the posttest (-14.4%). It appears that students are still having difficulty applying the concept of a calorie to an everyday situation. It is recommended that the developers provide additional examples, perhaps through teacher support materials, that will assist learners in understanding the application of how the energy of a calorie is used by an individual.

Teacher Implementation

Sixty-one teachers pilot-tested at least one chapter with students. Fifty-six teachers piloted-tested Chapter 7 (six pilot tested with two groups of students due to semester block scheduling), 51 teachers pilot-tested Chapter 8 (three pilot tested with two groups of students due to semester block scheduling), and 33 teachers pilot-tested Chapter 36 (one pilot tested with two groups of students due to semester block scheduling). Appendix B, available online at **http://www.lehigh.edu/~inexlife/nsfreport2/b.pdf**, displays the results of the post-implementation surveys for each *Exploring Life* chapter.

There was substantial variance in the amount of time teachers used chapter materials in their classroom. Teachers predominately had students use computers individually or within a group. Computers were used for whole classroom demonstrations to a lesser extent. Very few teachers reported using computers as learning stations or activity centers. One teacher reported that her students used a Smartboard to work through the Web-based materials.

Teachers used a variety of instructional methods to implement *Exploring Life* chapter materials in the classroom. Table 7 summarizes the reported methods of instruction. Most instructional time was spent with computer-based concepts and interactivities, followed by textbook use, lecture, laboratories, and discussion. Demonstrations were used to a lesser extent. The amount of time teachers used a particular instructional method in their classrooms varied substantially.

Individual teachers selectively chose from a variety of Web-based instructional materials to meet their curricular objectives and accommodate the diverse learning needs of their students. Table 8 summarizes the percentage of use of each Web-based materials type. Appendix C, available online at **http://www.lehigh.edu/~inexlife/nsfreport2/c.pdf**, lists the reported reasons teachers did not use a specific Web-based material type in their classroom for all three chapters.

Table 7. Mean reported methods of instruction percentages.

Method of instruction	Mean Ch.7 (n=62)	Mean Ch.8 (n=54)	Mean Ch.36 (n=34)	Grand Mean
Exploring Life Website activities on computer	46.25%	52.84%	57.85%	52.31%
Textbook	27.08%	22.86%	25.74%	25.23%
Lecture	22.73%	23.50%	25.00%	23.74%
Laboratories	22.01%	17.69%	18.21%	19.30%
Discussion	18.94%	13.09%	13.21%	15.08%
Demonstration	8.33%	9.00%	7.50%	8.28%

Table 8. Web-based material use summary

Web-based material type	N	Percent Teacher Use Mean for 3 chapters	Percent Teacher Use Range for 3 chapters
Interactive Concepts	14	97.2%	88.9 – 100.0%
Quiz	3	69.7%	64.7 – 75.8%
Closer Looks	3	67.8%	63.0 – 72.6%
Webquests	3	66.3%	59.3 – 73.5%
Laboratories	4	51.3%	30.6 – 66.1%
Explore!	2	50.6%	41.9 – 59.4%
Career	1	41.2%	41.2%

Most teachers implemented each Interactive Concept in their classrooms. The Interactive Concepts were completed by students in a shorter period of time than most of the other activity types. Each Interactive Concept is integrated with a concept presented in the text. Open-ended survey responses indicated that teachers valued the integration of the Web and text components. Some open-ended responses noted that the guidance and feedback provided in the Interactive Concepts reinforced the information presented in the text and the simulations aided students in understanding biological processes. Interactive concepts not used by teachers were predominantly located at the end of the chapter sequence and the reasons usually given for not using them were that they were too complex or too detailed for the ability level of their students.

Data from the implementation surveys and teacher interviews revealed that time was a major factor in determining which activities a teacher would use in the classroom. Many school-based biology curricula are "very content heavy," requiring teachers to cover certain topics in a specified amount of time. This curricular time constraint plays a large role in influencing activity selection decisions. The teachers who did not use the laboratories, Webquests, Career, or the Explore! activities cited time constraints as being the main reason why those activities were not used in the classroom. Of particular note, the Fastplants guided research laboratory, a multi-day inquiry laboratory, was not used by 69.4% of the teachers that pilot tested Chapter 7. Activities that required at least a classroom period to implement were used to a lesser extent than the Interactive Concepts.

In addition to time constraints, the following reasons cited for not using a Web-based material type were noteworthy:

- Webquests: Technical problems and slow Internet connection.

- Laboratories: Difficulty with lab materials, did not have or receive lab materials, and experienced difficulty in getting the lab to work.
- Explore!: Concept covered in another topic.
- Quizzes: A written quiz was used instead.
- Closer Looks: Too advanced or detailed for students.

In response to Likert-scale items, the majority of teachers agreed that they found enough diverse activities to select what was needed in the chapter (81.7% for Ch.7; 72.2% for Ch. 8; 78.1% for Ch. 36). In addition, most teachers agreed that the modes of instruction were developmentally appropriate for their students (79.0% for Ch. 7; 70.4% for Ch. 8; 81.8% for Ch. 36).

Summary of Student Attitude Measures

The *Exploring Life* student attitude surveys were completed by 3,673 students (2,696 responses for Chapter 7; 2,598 responses for Chapter 8; and 1,325 responses for Chapter 36). Student attitude surveys consisted of twenty-seven Likert-type questions designed to determine which features of the *Exploring Life* materials assisted student learning and to provide the developers with feedback on the design of materials. Students completed an attitudes survey after using a chapter. Appendix D, available online at **http://www.lehigh.edu/~inexlife/nsfreport2/d.pdf**, displays the results of the student attitudes surveys for each *Exploring Life* chapter and the items leading to each finding below are indicated in parentheses following that finding. Student response to individual items was homogeneous across all three chapters with most items varying only two to three percent.

- The "virtual demo labs" and the hands-on classroom laboratories helped students understand the biology concepts. (Items 11-12)
- Features of the Web-based instruction assisted student learning. These included receiving immediate feedback to responses, being able to perform activities over and over again, and having user control of the interactivities. (Items 18, 19, 21)
- The design of the computer activities and textbook are appropriate for the grade level of students. (Items 3-5)
- The amount of reading and vocabulary level are appropriate for the grade level of students. (Items 1-2)
- The majority of students reported that they would like to use the computer activities either every day or once or twice a week. (Item 14)
- The majority of students reported they preferred using more or the same amount of animations and hands-on laboratories. (Items 8, 10)
- The majority of students reported they would prefer using the *Exploring Life* computer activities on their own after a teacher lecture or with classmates without a teacher lecture. (Item 13)
- The majority of students noted they preferred *Exploring Life* to their regular textbook. (Item 15)

- Approximately half of the students did not look at the Website outside of their class. Of those that did, most wanted a chance to complete something that was not finished in school. (Items 16-17)

According to 34.2% of the students, the animations in Chapters 7 and 8 were complicated. A lower percentage of students, 21.3%, responded that the animations in Chapter 36 were complicated. (Item 6) This finding might be attributed to the complex biochemical pathways that are presented in the Closer Looks in Chapters 7 and 8.

Many students reported that the movement and action in the interactivities distracted them from learning concepts. (Items 22) This finding might be attributed to a novelty effect.

In interviews, students reported that the animations and interactivities helped them understand the biology concepts.

The data indicate that the interactivities and graphics on the Website are helping lower level students and low-level readers understand the main concepts. Significant increases in content knowledge assessments were noted in inclusive biology classrooms.

Computer implementation issues

Communication problems between teachers and technical support staff. It is evident that some (perhaps many) classroom teachers do not understand how to determine if their computers meet minimum software and hardware requirements. During field observations, it was noted that communication problems exist between classroom teachers and technology support staff. These two groups often appear to speak different languages. In some cases, it appeared that the classroom teachers did not know the right questions to ask the support staff in order to get computers properly configured. These findings have also been reported in personal e-mail correspondences from other pilot participants.

Locus of control/discipline battles. Some participants choose not to fight the "management battles" of students being on-task in the computer lab as much as they do in their own classroom. Interview data reveal that teachers are more comfortable in their own classroom than in a computer lab.

Students with disabilities. Field observations revealed that visually impaired students had difficulty accessing the content provided in the interactive animations with their adaptive software. It was recommended that equivalent alternatives be encoded in important areas of the Web-based materials (e.g., Flash interactivities, video, images, etc.) to ensure that important content may be accessible to all users.

Publications and Products

Exploring Life Community Website
http://www.usingexploringlife.com

This is a site designed to provide a place for teachers, administrators, and parents to discover more information about the *Exploring Life* program than a typical sales brochure can provide. The Website will provide a virtual space to share information about using *Exploring Life* in the classroom with other interested teachers.

Manuscripts submitted

Bodzin, A., Price, B., Cates, W., Williamson, B., Campbell, N. and Heyden, R. (In review). Formative evaluation of the design and development of a Web-integrated biology curriculum. Journal of Computers in Mathematics and Science Teaching.

Cates, W., Price, B., and Bodzin, A. (In review). Challenges in implementing technology-rich curricular high school biology materials: First year findings from the *Exploring Life* project. Computers in the Schools.

Training and Development
What research and teaching skills and experience has the project helped provide to those who worked on the project?

High school biology teachers used the AIBS/Packard review instrument with additional items from the AAAS criteria for evaluating the quality of instructional support instrument to evaluate the *Exploring Life* curricular materials. What makes this procedure unique and particularly helpful is that it enables educators to examine curricular materials against specific science literacy goals, such as those identified in National Research Council's *National Science Education Standards* and the Project 2061's *Science for All Americans* and *Benchmarks for Scientific Literacy*. This activity served as a powerful professional development experience for our teacher participants. In particular, it enabled teachers to think seriously about standards and their implications for curriculum content and instruction.

High school biology teachers used the Web-based Inquiry (WBI) for Learning Science instrument to gain a theoretical and practical understanding about how to take advantage of Web-enhanced instructional materials and approaches to promote inquiry learning with classroom students. This activity enables teachers to understand the variations of inquiry and how they align with the learning goals of classroom students. This entailed exploring when it is appropriate to implement materials-directed inquiries, when it is better to use more learner-directed approaches, and how best to take advantage of the Web to support inquiry learning in differing classroom contexts. Analyzing WBIs provided many

opportunities to discuss instructional, curricular, and technological supports that may aid students in the inquiry process. These discussions addressed the nature of Web-based collaborative inquiry, the role of using scientific visualizations to promote learning, provisions in the instructional design of materials to motivate learners, the role of scaffolding in reducing the complexity of a task, and design features for promoting autonomous learning.

Outreach Activities
What outreach activities have you undertaken to increase public understanding of, and participation in, science and technology?

1. The *Exploring Life* project was presented in the following national conference presentations:

- Bodzin, A., Price, B., & Heyden, R. (2001, November). A formative evaluation approach to guide the development of a Web-text biology curriculum. Paper presented at the National Association of Biology Teacher's annual meeting (NABT) in Montreal, Quebec.
- Bodzin, A., Williamson, B., & Price, B. (2002, March). Learning biology with a Web-enhanced curriculum. Presentation session presented at the 2002 National Science Teachers Association (NSTA) National Convention in San Diego, CA.
- Campbell, N., Williamson, B., & Heyden, R. (2002, March). *Exploring Life*: Meet the authors. Presentation session presented at the 2002 National Science Teachers Association (NSTA) National Convention in San Diego, CA.
- Bodzin, A., Price, B. Cates, W. Williamson, B., &d Campbell, N. (2002, April). Formative evaluation of the design and development of a web-based biology curriculum: Y1 findings. Paper presented at the National Association for Research in Science Teaching Annual Meeting in New Orleans, LA.
- Bodzin, A., Price, B., Cates, W., Heyden, R., & Weidenaar, J. (2002, June). Developing a web-enhanced high school biology program. Web poster session presented at the 2002 National Educational Computing Conference (NECC) in San Antonio, TX.
- Price, B., Cates, W., & Bodzin, A. (2002, June). Challenges in implementing technology-rich curricular high school biology materials: First year findings from the *Exploring Life* project. Paper presented at the National Educational Computing Conference in San Antonio, TX.

2. Year 2 conference papers and information about the *Exploring Life* evaluation have been continuously updated on the *Exploring Life* Evaluation Website.
URL: http://www.Lehigh.EDU/~inexlife/

3. An *Exploring Life* Community Website has been developed.
URL: http://www.usingexploringlife.com