

Investigating Life NSF Year 1 Annual Report - Activities and Findings

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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, consistent with the National Science Education Standards, should also be enhanced.

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 AAAS criteria for evaluating the quality of instructional support instrument, feedback questionnaires, focus group questions, field observations, teacher journals, post implementation surveys, student reaction journals, teacher and student interviews with open-ended questions, and pre- and posttest content knowledge quizzes. Data instruments are available online at: <http://www.lehigh.edu/~inexlife/evaluation/>.

Forty-two high school biology teachers selected from a stratified sample of thirteen distinct geographical regions that included Alaska and Hawaii participated in the evaluation of the Exploring Life materials during the first year of the grant implementation period. The participants reviewed the Exploring Life Web-based and text materials in various stages of development at one of three evaluation workshops. Workshops were held in August 2000, October 2000, and March 2001. Feedback and recommendations resulting from the evaluation workshops were reported back to the

development team. A complete list of these reports is available at:
<http://www.lehigh.edu/~inexlife/evaluation/>.

A prototype chapter (Unit I, Chapter 4) for cellular respiration was developed prior to the August workshop. The prototype is available online at: **<http://elstaging.peregrine-pub.com/>**. To access the prototype material, use *life* as the User name and *liberty* as the Password. A copy of the Website is also available on the *Exploring Life Year 1 CD-ROM*.

Feedback from the first evaluation workshop, the interface analysis reports, and initial pilot testing with classroom students resulted in the development of rapid prototypes of two new interfaces for Exploring Life. Rapid prototyping allows for rapid construction of different design approaches for the purpose of evaluating strengths and weaknesses of the instructional system interface before full-scale production. Participants in the October 2000 workshop evaluated both rapid prototypes. These two prototypes can be viewed on the *Exploring Life Year 1 CD-ROM*. Participant feedback about the prototypes and the interface analysis reports led to adopting a new interface design for Exploring Life.

The cellular respiration and photosynthesis chapters were developed using the new interface design prior to the March 2001 evaluation workshop. An ecology chapter was developed in May 2001. The most current version of the materials is available online at: **<http://www.biology.com/elife>**. To access the Website, use *elife* as both the User name and Password. This Website must be viewed with Internet Explorer version 5.0 or higher and have the latest Flash 5.0 plug-in installed. The March and May versions of the Website may also be viewed locally on the *Exploring Life Year 1 CD-ROM*.

During the first year of the grant implementation period, eighteen participants pilot tested Exploring Life materials with 783 students. The evaluation team conducted five field observations. Field observations and implementation reports are available at: **<http://www.lehigh.edu/~inexlife/evaluation/>**. Each report has been discussed with the development team and the recommendations made by the evaluation team have been acted upon. Throughout the first year of the project, close, almost daily contact has occurred among the evaluation team, the development team, and the teacher pilot testers.

Summary of major accomplishments

- The current version of the Exploring Life interface is easy to use for both teachers and students. The interface problems observed with the prototype chapter have been addressed and corrected.
- Participants rated the interaction between the text and the Website as a major strength of Exploring Life. Biology teachers noted that the Website simplifies biological concepts and presents real-life examples and applications of the concepts to which students can relate to. Students reported that the Web-based interactivities help them learn the biology concepts.
- Many Exploring Life activities involve active learning. Students appeared to be physically and mentally involved in the activities.
- Pre- and posttest results of biology content knowledge reveal that students are learning the biology concepts and content using the Exploring Life materials.
- Preliminary data indicates that the interactivities and graphics on the Website are helping students with individual learning programs (special needs) and lower proficiency readers understand the main concepts.
- Preliminary data indicates that Exploring Life is a flexible program that will allow biology teachers to pick and choose from a variety of types of activities to use with their students.
- The integration of sections between the text and the Website is perceived by the biology teachers to be less threatening and less intimidating for their students than using a textbook chapter alone. The chapters are broken down into manageable sections for learners.
- The Exploring Life listserv is serving as a community support network and an ongoing discussion forum among the developers, the teachers, and the evaluation team. The listserv is being used to share ideas, request information on biology content, and for soliciting assistance to solve technology implementation issues. The listserv is also being used to elicit ideas and feedback from the teachers to assist with development decisions.

Major Findings from NSF activities

Description of project activities for the year

Three evaluation workshops were conducted at different developmental stages during the first 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 1

Workshop	Materials Evaluated	Data Collection
Lehigh University August, 2000 (18 participants -- included 1 preservice teacher and 1 science supervisor)	<ul style="list-style-type: none"> • Prototype cellular respiration chapter • Conducted FastPlants laboratory 	<ul style="list-style-type: none"> • Evaluator observations: Usability • AAAS criteria for evaluating the quality of instructional support instrument • Survey - grant objectives • Focus groups
NABT October, 2000 (11 participants)	<ul style="list-style-type: none"> • Revised prototype cellular respiration chapter • Rapid prototypes for new interface (Traylor Media and Redhill Studios) 	<ul style="list-style-type: none"> • Evaluator observations: Usability • AAAS criteria for evaluating the quality of instructional support instrument • Survey - grant objectives • Focus groups • Rapid prototype responses
NSTA March, 2001 (15 participants)	<ul style="list-style-type: none"> • New interface • Revised cellular respiration chapter, photosynthesis chapter • Teacher Resource prototypes 	<ul style="list-style-type: none"> • Evaluator observations: Usability • AAAS criteria for evaluating the quality of instructional support instrument • Survey - grant objectives • Focus groups • Small group open-ended questions

The evaluation team conducted five 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 features and the development of new interactivities. Resulting modifications to the Website were evaluated in each succeeding workshop and by our interface design expert. Many of our first workshop participants pilot tested the Exploring Life materials in their classroom during the 2000-01 school year. Students completed pre- and posttests for biology content knowledge and concepts before and after using the chapter materials. After students completed a chapter, each teacher submitted a post-implementation survey and a journal with open-ended responses. Follow-up phone interviews were conducted with selected teacher participants. Currently, the development team is modifying the existing chapters and producing additional text chapters, laboratories, and Web components.

Evidence of the effectiveness of the efforts

Significant product improvements have been made in the design of the instructional materials since the original prototype chapter. Table 2 summarizes the changes made to the prototype chapter of Exploring Life as a result of the NSF evaluation feedback. The resulting modifications were used in the development of additional media for succeeding chapter development.

A comparison of the original prototype with the current version of Exploring Life reveals many differences in the design of the materials with the intent of enhancing student learning. 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.

During the first evaluation workshop, novice computer user participants had difficulty navigating within the prototype Website. This was especially evident with activities that contained hypertext links to Websites located outside of the Exploring Life host server (for example, CalorieQuest and Explore). Participants experienced high frustration levels using these activities. They had difficulty navigating back and forth between two browser windows, and, in many cases, had difficulty locating their second browser window. A few participants lost data by inadvertently closing their browser windows. Interface recommendations to the development team led to a new interface for these activities. Participants using the new interface in the third evaluation workshop did not experience navigational difficulties as in the previous workshops with the prototype chapter. 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 fast. Students log on to their computers and are able to enter a specific *Concept* in less than a minute.

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

Instance Prior to Feedback	Evaluation Feedback	Resulting Product Change
<p>The prototype chapter did not have adequate "teacher resources" available to assist teachers in using Exploring Life with their students.</p>	<ol style="list-style-type: none"> The evaluation team made recommendations for the "teacher resources" section based on the results from the AAAS criteria for evaluating the quality of instructional support instrument, workshop surveys and focus group responses. Pre- and posttest content assessments revealed students' misconceptions. 	<ol style="list-style-type: none"> Current Website contains a revised "teacher resources" section that includes alternative assessment ideas, suggestions for teaching in different computer settings, troubleshooting suggestions, tips for teaching each concept, hypertext links to additional content information, and examples of student data. A "teaching for conceptual change" section of the teacher resources is currently under development.
<p>User interface issues:</p> <ol style="list-style-type: none"> The concept backbone structure. Showing the relationship between labs/explores and their parent concepts. Color scheme Confusion over how to page forward within an activity and the function of the breadcrumb (navigation trail) feature. Difficulty finding and reading instructions for the activities. 	<ol style="list-style-type: none"> Teachers had trouble understanding how each Website component related to the entire site. User interface recommendations made. Teachers expressed confusion over the different types of activities and how they all fit together. User interface recommendations made. Teachers expressed concern that the screen looked too bland. Color scheme recommendations made. After completing an activity, students and teachers had trouble figuring out how to page forward. Many did not understand the page stepper and most did not use the breadcrumb (navigation trail) feature. User interface recommendations made. Learners would scan the text for specific instructions, not bothering to read carefully. User interface recommendations made. 	<p>See new user interface on the Website:</p> <ol style="list-style-type: none"> New concept backbone as it appears on the chapter table of contents and on each activity page. New concept backbone. New color scheme. Page stepper was revised for greater clarity and put in its own frame so it became enduring no matter where the user was located in the activity. The breadcrumb (navigation trail) was increased in size and colored blue to make it more obvious to the user. Developers added a blue instruction box to each activity to house specific interactive instructions. The type size was increased for ease of reading.
<p>Chapter 7 Cellular Respiration Pre-/Posttest Question #5: All work requires a source of _____.</p>	<p>A few student scores on this test question decreased from pre- to posttest. Students selected ATP from the answer choices, erroneously concluding that all work required ATP. This was most likely due to the chapter's strong focus on ATP.</p>	<p>Authors revised Chapter 7 to make clear that ATP was one source of energy.</p> <p>See Concept 7.2, page 4, <i>Food Stores Chemical Energy</i>.</p>
<p>Chapter 7, Concept 7.4 Electrons fall from food to oxygen during cell respiration. Online activity: <i>The Snowboarder</i></p>	<p>The keyboard controls were difficult to use and the snowboarder analogy wasn't a perfect one for the concept. Some student confusion.</p>	<p>Media team scrapped the activity. A new 7.4 interactivity was developed that more accurately presented the concept without using keyboard controls.</p>

<p>Animations played through from beginning to end at the click of a start button.</p>	<p>Teachers and students expressed the need for more user control. Their concern came in the form of "speed control." Recommendations made to increase the user's control over the animations by segmenting animations into smaller components.</p>	<p>While developers could not offer varying speeds to play the QuickTime animations, they did adapt the standard QuickTime controller at the bottom of the animation window to show a content progress bar. This enabled the user to access relevant segments of a complex (or long) animation quickly when they wanted to replay it. See Concept 7.1 activity (<i>Bear in the Apple Tree</i>). Chapter 8 animations were developed with this revised format.</p>
<p>Animations were populated with teenagers to give the product a high school feel and a more personal, human touch.</p>	<p>Teachers pointed out that the animations looked too young and reminded us that teenagers think of themselves as older than they are. The inclusion of these younger-looking teens might make the material less interesting and attractive to them.</p>	<p>The developers removed the original characters, replacing them with photos for context-setting scenes. These contained adults or animals in areas where organisms needed to be animated.</p>
<p>Chapter 7, Concept 7.5 Cellular respiration converts food energy to ATP energy. A pinball animation showing the basic mechanisms of Glycolysis, Krebs Cycle, and Electron Transport</p>	<p>Teachers and students expressed the need for more user control. Participants' concern took the form of "this activity is too long, there's too much going on for the student to absorb everything."</p>	<p>The developers segmented the animation. Summaries of steps were provided to break the animation into manageable chunks and to slow it down. See Concept 7.5</p>
<p>Students and teachers noted they were frequently confused over the purpose of some activities, particularly the longer, multi-part interactivities.</p>	<p>The evaluation team suggested that each activity should contain a goal statement to make its purpose clearer to the learner. Furthermore, expected outcomes of the activity should be explicitly distinguished.</p>	<p>Goal statements were added to each concept activity. See any activity on the current version of the site.</p>

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 of Exploring Life 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 1 evaluation. Each instrument can be viewed at <http://www.lehigh.edu/~inexlife/evaluation/>. These include:

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. *AAAS Criteria for evaluating instructional support.* This evaluation instrument examines how well the instructional materials are likely to help students learn the important ideas and skills in the widely accepted Benchmarks for Science Literacy and in the National Science Education Standards. Biology teacher participants completed this after each evaluation workshop.
3. *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).
 - a. *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 1.5 hours. Each biology teacher participated in a focus group session after he or she worked through the materials.
 - b. *Site-based field observations.* Evaluation team members visited a sample of classrooms as an observer, gathering open-ended observations. Six classrooms of students were observed using the Exploring Life materials in different developmental stages.

- c. *Expert Analysis.* An instructional design expert reviewed the materials and provided analyses and recommendations at different developmental stages of the Web-based materials.
4. *Attitude measures.* Biology teacher participants completed a post-implementation survey consisting of Likert-type and open-ended questions. These participants also submitted a journal that used open-ended questions. These instruments were designed to address our four main formative evaluation questions:
 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?
5. *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.
6. *Student response journals.* A sample of students were asked to write a student reaction paper about their experience using the Exploring Life materials.
7. *Interviews with teachers.* Structured phone interviews were conducted with each Exploring Life teacher participant from the first two workshops who were unable to implement the materials with their classroom students.
8. *Computer experience questionnaire.* This instrument asks about past and current computer and Internet training, usage, skills, and confidence about computers and Web-based learning.

AAAS Criteria for evaluating instructional support

Table 3 displays the results of the AAAS Criteria for Evaluating the Quality of Instructional Support instrument. The main findings on the effectiveness of the Exploring Life program were based on teacher-participant responses (n=43) to the AAAS Criteria for Evaluating the Quality of Instructional Support Instrument. They include:

Strengths:

1. The material does a good job in conveying an overall sense of purpose and direction that is understandable and motivating to students.
2. The material conveys the purpose of each lesson.
3. The material involves students in a logical or strategic sequence of activities.
4. The material provides a sufficient number and variety of phenomena, observable events in nature that can make a scientific idea real to students.

5. The materials include activities that provide firsthand experiences with phenomena when practical and a vicarious sense of the phenomena when not practical. The experiences that are not firsthand (for example, text, pictures, animations, interactivities) provide students with a vicarious sense of the phenomena.
6. The materials introduce technical terms in conjunction with an experience with the idea or with a process. Terms are introduced as needed to facilitate thinking and promote effective communication. The material is effective in linking technical terms to relevant experiences rather than just having students learn definitions of terms.
7. The materials include accurate and comprehensible representations of scientific ideas. The interactivities provide a sufficient number and variety of representations that are explicitly linked to the presented concept and comprehensible to the students.
8. The materials provide a sufficient number of tasks in a variety of contexts, including everyday contexts. Furthermore, novel tasks are included.
9. Many of the online concept areas encourage students not only to express but also to clarify, justify, and represent their ideas. The Web-based materials include text that directly provides students with immediate feedback regarding their ideas.
10. The material includes specific and relevant tasks and/or questions for the experience or reading. There are examples throughout the material that use questions or tasks that have helpful characteristics. Examples include: framing important issues, helping students relate their experiences with phenomena to presented scientific ideas, helping students make connections between their own ideas and the phenomena observed, and helping students make connections between their own ideas and the presented scientific ideas.
11. The current Exploring Life material includes assessment items that require application of ideas and avoids allowing students a trivial way out, such as using a formula or repeating a memorized term without understanding. Some assessment items that appear in the "applying the concepts" section of the text include both familiar and novel tasks.
12. Exploring Life does contain materials that appear able to help teachers create a classroom environment that welcomes student curiosity, rewards creativity, encourages a spirit of healthy questioning, and avoids dogmatism. These materials include the CalorieQuest, the Wisconsin Fastplants lab, and the Explore It! activity.
13. The material avoids stereotypes or language that might be offensive to a particular group.
14. The material does suggest alternative formats for students to express their ideas during instruction and assessment. This is evident where students report their laboratory results in the form of mini-posters or are provided suggestions to give a report or to create a PowerPoint presentation.

Weaknesses:

- Currently, the Exploring Life chapter materials do not specify prerequisite knowledge (prior knowledge or understanding that learners need to be able to learn new content or concepts) or skills that are necessary to meet the benchmark(s) for learning. The materials in Chapter 8 do contain links to content presented in Chapter 7.
- The Exploring Life chapter materials do not alert teachers to commonly held student ideas (some of which are troublesome and some helpful).
- The current Exploring Life Teacher Resource materials do not demonstrate/model or include suggestions for teachers on how to demonstrate/model skills or how to use the knowledge that is presented in the chapter.
- The material does not include specific suggestions to help teachers provide explicit feedback or include suggestions on how to diagnose student errors, give explanations about how these errors may be corrected, or how to further develop students' ideas.
- The material does not appear to provide students a way of expressing initial ideas about the content and concepts presented in the material. Furthermore, the material does not engage (or provide specific suggestions for teachers to engage) students in monitoring how their ideas have changed periodically in the unit.
- The materials do not contain a variety of alternative assessment items. Additional types of assessment could be included in the development of the materials including open-ended questions, essays, and lab practicals. Rubrics could be developed to score these assessment items.
- The material does not provide specific suggestions to teachers about how to use the information from the embedded assessments to make instructional decisions about what ideas need to be addressed by further activities.
- The material currently does not suggest how to probe beyond students' initial responses to clarify and further understand student answers.

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 AAAS Criteria for Evaluating Instructional Support Instrument.
[Rating scale: Excellent (3), Good (2.5-2.9), Satisfactory (2.0-2.4), Fair (1.5-1.9), Poor (0-1.4)]

Criteria for evaluating the quality of instructional support		Prototype (n=28)		New interface (n=15)	
		Mean	sd	Mean	sd
I.1	Conveying unit purpose	2.45	0.85	2.67	0.49
I.2	Conveying lesson purpose	2.43	0.50	2.67	0.62
I.3	Justifying activity sequence	2.71	0.46	2.80	0.41
II.1	Attending to prerequisite knowledge and skills	1.41	1.31	1.93	0.96
II.2	Alerting teacher to commonly held student ideas	1.29	1.24	2.27	1.03
II.3	Assisting teacher in identifying own students' ideas	2.04	0.94	1.67	1.11
II.4	Addressing commonly held ideas	2.11	0.88	2.20	0.86
III.1	Providing variety of phenomena	2.85	0.36	2.67	0.82
III.2	Providing vivid experiences	2.81	0.40	2.47	0.83
IV.1	Introducing terms meaningfully	2.81	0.40	2.60	0.63
IV.2	Representing ideas effectively	2.83	0.37	2.67	0.49
IV.3	Demonstrating use of knowledge	1.62	1.30	2.13	0.99
IV.4	Providing practice	2.77	0.43	2.67	0.49
V.1	Encouraging students to explain their ideas	2.27	0.83	2.47	0.52
V.2	Guiding student interpretation and reasoning	2.42	0.79	2.73	0.59
V.3	Encouraging students to think about what they've learned	2.00	1.10	2.07	0.96
VI.1	Aligning assessment to goals	2.21	1.02	2.33	0.90
VI.2	Testing for understanding	2.46	0.83	2.53	0.92
VI.3	Using assessment to inform instruction	1.91	1.08	1.73	1.03

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. The alpha level for determining a significant difference between matched pretest and posttest performance was set at .05.

Results

The scores of the pretests and posttests for both interfaces of the Cellular Respiration chapters show that students' content knowledge increased significantly. (See Tables 4 and 5). Table 6 shows the percentage of each item that was answered correctly on the content assessments for the Ch.4 prototype. Table 7 shows the percentage of each item that was answered correctly on *The Working Cell: Energy from Food* (Ch.7) content assessments with the revised content and new interface. On the Ch.7 content assessment, the percentages of 11 of 12 items increased on the posttest. The percentage increases are

considered good. The score of question 6 decreased on the posttest (-12.21%). It appears that students are having difficulty applying the concept of a calorie to an everyday situation. It is recommended that the developers provide additional examples, perhaps through Web-based interactivities, that will assist learners in understanding the application of how the energy of a calorie is used by an individual.

The scores listed in Tables 4 and 5 indicate that students are learning from the materials. We feel that the developers are on the right track. We cannot say how the scores compare to students who are not using the Exploring Life materials. We will examine this during Year 2 of the study.

Modest percentage increases were noted for posttest questions 1, 4, 5, and 11 (See Table 5). We will need to investigate further why we did not observe larger increases on the percentages on these posttest question items. We will be administering performance assessments to a sub-sample of learners to clarify these issues during Year 2 of the study.

Table 4. Analysis of Content Assessment Item Scores from *The Working Cell: Energy from Food Prototype*. (n=478)

Question number	Ch.4 Pretest % correct	Ch.4 Posttest % correct
1	58.85	73.43
2	38.92	71.16
3	46.25	80.08
4	52.95	63.19
5	70.18	69.64
6	71.61	68.12
7	35.09	60.72
8	31.42	49.72
9	17.86	35.86
10	25.36	46.30
11	60.45	66.03
12	35.73	60.15
MEAN	5.388	7.441
t-TEST	t=18.639	df=477 p<.001

Table 5. Analysis of Content Assessment Item Scores from Revised *The Working Cell: Energy from Food* (n=213)

Question number	Ch.7 Pretest % correct	Ch.7 Posttest % correct	% change
1	63.38	73.24	+9.86%
2	33.80	77.93	+44.13%
3	43.66	85.92	+42.26%
4	56.81	66.67	+9.86%
5	69.01	72.77	+3.76%
6	67.61	55.40	- 12.21%
7	26.76	59.62	+32.86%
8	37.09	54.46	+17.37%
9	15.49	46.95	+31.46%
10	28.64	68.08	+39.44%
11	55.40	64.79	+9.39%
12	37.56	67.14	+29.58%
MEAN	5.352	7.930	+21.2%
T-TEST	T=15.110	df=212	p<.001

Students' knowledge of the Chapter 8 - *The Working Cell: Energy from Sunlight* content increased significantly. Table 6 shows the percentage of each item that was answered correctly on this chapter's content assessments. Percentage gains were observed on 16 of 17 assessment items.

- Only a modest posttest increase was observed for question 10. Question 10 addresses a common misconception. It is recommended that better teacher support materials be included to present strategies for teaching conceptual change for understanding processes that occur during both photosynthesis and cellular respiration.
- Only a modest posttest increase was observed for question 14. This activity is presented in Concept 8.3, page 3 on the Website. We cannot say how the scores compared between students who were assigned this concept and those who were not assigned this concept. In Year 2, we will look at the distribution of scores for this test item for students assigned this activity in their classroom and those not so assigned.
- Students' percentage scores decreased (-5.81%) on posttest question 16. This is a difficult application of the materials presented in Concept 8.4 of the Website. We cannot say how the scores compared between students who were assigned this concept and those who were not assigned this concept. In Year 2, we will look at the distribution of scores for this test item for students assigned this activity in their classroom and those not so assigned.

Table 6. Analysis of Content Assessment Item Scores from Chapter 8 - *The Working Cell: Energy from Sunlight*. (n=86)

Question number	Pretest % correct	Posttest % correct	% change
1	32.56	62.79	+30.23%
2	36.05	68.60	+32.55%
3	51.16	60.47	+9.31%
4	33.72	54.65	+20.93%
5	36.05	60.47	+24.42%
6	23.26	43.02	+19.76%
7	33.72	63.95	+30.23%
8	13.95	31.40	+17.45%
9	11.63	32.56	+20.93%
10	18.60	20.93	+2.33%
11	26.74	46.51	+19.77%
12	30.23	48.84	+18.61%
13	34.88	41.86	+6.98%
14	29.07	38.37	+9.30%
15	16.28	45.35	+29.07%
16	25.58	19.77	-5.81%
17	26.74	43.02	+16.28%
MEAN	4.810	7.826	+17.7%
t-TEST	t=9.940	df=85	p<.001

The content assessment scores of the pretests and posttests of Chapter 36 - *The Biosphere* shows that students' content knowledge increased significantly. Table 7 shows the percentage of each item that was answered correctly on the content assessments. Percentage gains were observed on 12 of 15 assessment items.

- A posttest percentage decrease (-3.84%) was observed on question 6. It appears that students did not understand the process of global air circulation. This topic is presented in Concept 36.2 on the Website. Field observations noted that students had difficulty understanding the animations in this concept. It was recommended that the developers modify the content in this section.
- A 5.13% decrease in posttest performance was observed for question 9. This is a low-level recall question from the textbook.
- A posttest percentage decrease of 12.82% occurred on question 11. It appears that students are having difficulty applying the concept of the interrelationship of biotic and abiotic factors in an ecosystem. It was recommended that additional examples be included in the teacher support materials to assist teachers in teaching this concept.
- Only modest increases were observed for questions 1-4, 7-8, and 13. These are low-level recall questions from the textbook.

Table 7. Analysis of Content Assessment Item Scores from Chapter 36- *The Biosphere*. (n=78)

Question number	Pretest % correct	Posttest % correct	% change
1	82.05	85.90	+3.85%
2	64.10	71.79	+7.69%
3	60.26	67.95	+7.69%
4	52.56	55.13	+2.57%
5	35.90	61.54	+25.64%
6	14.10	10.26	-3.84%
7	7.69	15.38	+7.69%
8	71.79	76.92	+5.13%
9	29.49	24.36	-5.13%
10	20.51	43.59	23.08%
11	39.74	26.92	-12.82%
12	24.36	38.46	+14.10%
13	39.74	47.44	+7.70%
14	23.08	41.03	+17.95%
15	19.23	52.56	+33.33%
MEAN	5.770	7.215	+21.6%
t-TEST	t=4.789	df=77	p<.001

Summary of attitude measures

Table 8 displays the results of the post-implementation surveys for the Exploring Life chapters. It should be noted that the Exploring Life teacher support materials were not fully developed during the implementation of these materials. In general, these results indicate that the teachers reported that the Exploring Life Cellular materials actively engage students in learning biology. They utilize some features of inquiry in the delivery of content. They contain unit topics and modes of instruction that are developmentally appropriate for the majority of the sampled population of students. Finally, the materials were perceived to address important goals of biological science teaching and learning.

Table 8. Post-implementation Likert Item Survey Responses

Scale: 1-Strongly disagree, 2- Somewhat disagree, 3- Neutral, 4- Somewhat agree, 5-Strongly Agree

Item	Ch.4 Avg.	Ch.4 SD	Ch.7 Avg.	Ch.7 SD	Ch.8 Avg.	Ch.8 SD	Ch.36 Avg.	Ch.36 SD
The Exploring Life materials promote constructivist learning in the biology classroom	4.43	0.53	4.25	0.46	4.33	.52	4.25	.50
The Exploring Life materials encourage active learning for all students.	4.29	0.76	4.12	1.13	4.33	.52	3.75	1.26
The Exploring Life materials did not improve my students understanding of fundamental biological concepts.	1.86	1.07	2.00	0.93	2.50	.84	2.00	.82
The Exploring Life materials helped to increase my students self-confidence in and skill in scientific reasoning and inquiry.	3.57	0.79	3.50	0.76	3.83	.75	3.00	1.15
The Exploring Life materials enhanced my students ability to apply biological knowledge and the methods of science to important social issues.	3.71	0.49	3.25	1.39	3.33	1.03	3.00	1.15
The Exploring Life teacher support materials assisted me in implementing the materials in my classroom.	3.86	0.38	2.88	1.55	3.17	1.17	4.25	.50
Inquiry is the basis of the learning experience with the Exploring Life materials.	4.43	0.53	4.12	0.35	3.67	1.03	3.50	1.73
The topics of the Exploring Life chapter and the modes of instruction are developmentally appropriate for my students.	4.14	1.21	4.14	1.22	4.33	.82	3.33	1.15

Note. Number of respondents: Ch.4 = 7; Ch.7 = 7; Ch.8 = 6; Ch.36 = 4.

The animations were viewed as a major strength of Exploring Life by both teachers and students. During the evaluation workshops, the teachers noted that the animations would help students understand the content presented in the chapter and learn the concepts presented in the laboratory. Most teachers commented that the animations helped them to understand the laboratory procedures in Exploring Life. In interviews, students reported that the animations and interactivities helped them to understand the biology concepts. Segmenting animations into smaller chunks appears to have helped learners to understand the concepts that are presented in the materials.

Many learners responded that Exploring Life was interactive. They perceived Exploring Life as a better way of learning biology content than by learning biology with a textbook and "what the teacher normally does." The WebQuest (CalorieQuest) and Explore! (Lance Armstrong) were well received by the learners. They found these activities meaningful to their daily lives. The immediate feedback on the Website materials helped learners to understand the main points of the presented concepts.

Preliminary data indicate that the interactivities and graphics on the Website are helping lower level students and low level readers understand the main concepts. Some teachers noted that lower level students and students with learning disabilities appear to be more "on-target" with Exploring Life than with the regular biology program. One teacher noted substantial increases in her students' grades while they were pilot testing the cellular respiration and photosynthesis chapters.

Computer use

In general, most participants used the computers for over 50% of their class time. Most teachers had their students use the Exploring Life materials with one student per computer. Group work was the second most common way students worked with computers.

It appears that teachers had some technology issues when they used the Exploring Life materials. Participants experienced a variety of problems, including crashing computers, slow network connections, using the wrong Web browser, and the inability to load helper applications and plug-ins on computers.

Other findings pertaining to teachers' use of computers include:

- Teachers have difficulty structuring student use of computers. We are observing that there is a lack of pedagogical knowledge pertaining to incorporating technology into instructional contexts.
- Our data reveal that many teachers, despite their years of experience, are not accustomed to using computers with the students. Teachers will require time to adjust their pedagogical styles to teaching with learner-centered computer materials. The product will need to include a teacher section on computer hints and suggestions regarding how to use computers.
- There appears to be a need to provide biology teachers with training on how to incorporate the Web in their classroom.

- Teachers have difficulty scheduling tightly reserved computer labs.
- Teachers are not adapting the program to a one-computer classroom. Participants require instruction on how to use computers as learning stations.

Changes in the project

- Data from students will be collected on Scantron forms during years 2 and 3 of the grant implementation. These will be submitted to the evaluation team by mail using self-addressed stamped envelopes. Only 60% of Year 1 participants submitted data via the Web to our database. Forty percent of the data was received via mail and entered manually into our databases. The Year 2 and 3 budget will be revised to reflect these changes for mailing expenses.
- Post-implementation surveys have been modified on the basis of year 1 findings.
- A student attitudes survey will be administered to each student in addition to content assessments.

Preliminary notes about the evaluation process and findings

Attrition

We have experienced some attrition with our first group of participants. Most of the attrition resulted from technical issues with using the Web-based materials in their schools. After returning to their schools from the evaluation workshop, some participants realized they did not have the minimum hardware and software system requirements on their computers needed to use the Exploring Life materials. To resolve this issue, a test page with a Flash animation was designed on the *Exploring Life Call for Participation* Web page. Furthermore, additional screening was put into place for selecting participants to make sure their school computers had all necessary system requirements to use Exploring Life. Some participants removed themselves from the study for year 2 of the grant implementation period due to circumstances beyond their control (for example, change of teaching assignment, leaving their school system, etc.). Additional participants will be added to future workshops to compensate for this attrition.

Coordinating with the development' schedule

The publishing industry operates on a development time schedule that is different from the schedule to which academics are accustomed. Development usually occurs in components. Most initial time is spent developing the text first, followed by the development of mock-ups of individual Web components. Full media production does not occur until three or four months before the product goes to market. At this time, the publishing company contracts additional programmers to develop the Web-based materials. In order to provide the development team with the necessary feedback for implementing the Exploring Life product in the classrooms, negotiations had to be made with the publishing company to develop three chapters that included all components during the first year of the grant. Furthermore, due to the expense involved in developing a large-scale record-keeping database that will involve large back-end servers, an actual

record-keeping system cannot be pilot tested with our participants during the first two years of the grant. Direct e-mail submission of student work via embedded Web-based forms was used during the first five months of the pilot testing phase. This feature became inoperable when the new interface Website was relocated to a different server.

In the development of large projects such as Exploring life, deadlines are established in the development of specific areas. In some cases, once major decisions are made, modifications cannot be made until the next version of the product. For example, for this project, all decisions pertaining to the interface of the Website and the Teacher Resources section were finalized on May 15.

Training and Development

High school biology teachers used 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 Project 2061's *Science for All Americans* and *Benchmarks for Scientific Literacy* and the National Research Council's *National Science Education Standards*. 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.

Outreach Activities

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

- § Heist, M. and Bodzin, A. (2001, June). Effectively Integrate Existing Web Sites into a Traditional Curriculum. Web poster session presented at the National Educational Computing Conference (NECC) in Chicago. IL.
- § Bodzin, A., Heist, M., and Park, J. (2001, March). Enhancing science learning with visual Web-based instructional resources. Presentation presented at the National Science Teachers Association (NSTA) National Convention in St. Louis, MO.
- § Heist, M. and Bodzin, A. (2001, March). Making the A-list: Biology Web-based activities that really work in the classroom. Presentation presented at the National Science Teachers Association (NSTA) National Convention in St. Louis, MO.

- § Bodzin, A. (2000, November). Formative evaluation for a Web-based biology curriculum. Invited speaker. Presentation at the Learning Strategies for Science Education Websites meeting, Salt Lake City, UT.
- § Bodzin, A. (2000, November). Evaluation of Internet science programs. Chair of panel discussion at the Learning Strategies for Science Education Websites meeting, Salt Lake City, UT.

2. An Exploring Life Evaluation Website has been developed. This Website contains information on the NSF project. URL: <http://www.Lehigh.EDU/~inexlife/>

3. Lehigh University and Pearson Education developed a press release of the NSF grant. This has been sent to area newspapers of teacher participants.