Exploring Life Field Observation
Submitted by Dr. Al Bodzin with Dr. Lana Edwards

Teacher: Pat Waller (biology), Darlene Kale (special education)
School: Emmaus High School
Location: Emmaus, PA
Dates of field-testing prototype materials: January 9- February 22, 2002
Number of observation days: 17 days

Materials used: Chapters 7 and 8. After 5 days of implementation of Ch. 7, the class stopped using *ELIFE* for 5 days for semester exams. It was noted that some of the cellular respiration content was covered on this high-stakes test and needed to be covered prior to testing.

Number of classes: 3 (2 classes used Exploring Life curriculum; 1 class was a control group. The control group did not use the *ELIFE* materials. They were taught the content as the teacher would have normally taught the content without the prot0ype materials). Period 1: 6 learners with IEPs, Period 2: 3 learners with IEPs, Period 3: 6 learners with IEPs. Darlene is always present in periods 1, 2 and 3. Two additional special education aides are present in period 3. 24 students are rostered in each class. A few students were not present in the classroom during the entire field-testing time due to school suspensions. Many of these students are not intrinsically motivated to learn.

About Pat:
Pat has been a biology teacher for 35 years. 1.5 years ago, she considered herself to be a novice user of technology and became a pilot tester of Exploring Life as a way to grow professionally by placing her into a situation that will force her to use technology in her classroom. Pat piloted the Chapter 4 prototype with regular level and honors students last year. This year, she is teaching three classes of low level applied biology in an inclusive science classroom. The class is co-instructed with Darlene Kale, a veteran special education teacher. Pat also teaches two classes of honors level biology. It should be noted that Pat's honors biology classes had completed field testing the *ELIFE* prototype material.

Classroom characteristics:
Number of students: 24 rostered in each class
Level of students: 9th grade applied biology students, Lower level tracked, 6 students with IEPs in each class.
School socioeconomic level: Middle class, suburban school
Length of class period: 42-46 minutes

Computer lab setting: 20 operating PC Gateway 4200 in computer lab. An overhead Dukane projector is located in the lab, but there is no LCD projection device. All lights must be turned off in the room in order for the projection to be seen.

Classroom setting: Individual desks are lined up in rows. There are seven lab tables that seat four students along one side and the back of the classroom.
The classroom has one networked Macintosh Power PC hooked to a TV monitor. The resolution on the monitor is too small to view *ELIFE* materials for instructional purposes other than showing navigational features. The teacher has a Macintosh G4 on her desk.

The textbook, Biology Living Systems (Birds Glencoe, 1994) is used very sparingly with these students. Text reading is de-emphasized with these students. The students in this classroom rarely read the text in this class. These students have high levels of anxiety.

Role of the researchers: Both researchers were participant observers. Individual and small group questioning was sometimes used with the students to assist in making their thinking visible. After being present in the classroom after two week, Pat noted that we "had become part of the furniture". Discussion took place between the researchers and the teachers at the end of the three classes during Pat's preparation period. Any pedagogical changes resulting from these discussions are documented in a post implementation survey and an audio-taped interview that was conducted after the conclusion of the field-testing the prototype materials.

Selected Classroom Observations

Selected days of classroom observations are described. Seven weeks were spent implementing the Chapter 7 and 8 materials. This included the lab practical assessment. It should be noted that a hands-on chromatography lab was also implemented. This is a laboratory activity that Pat routinely does each year when teaching photosynthesis.
It should be noted that a quiz would be given each week to assess content and processes.

<u>January 9</u>

In the classroom, Pat has one computer hooked up to the TV monitor. She used this to show the navigation of the Website.

A handout is passed out with questions. The design of instructional is an information-seeking task. The handout provided an accountability measure for students to locate the main ideas and facts in the *ELIFE* materials.

In the classroom, guided worksheets are typically given to students a mechanism them to take ownership for their work. The teacher-constructed worksheets are aligned to the district curriculum and are designed to ensure the content on a high-stakes semester exam is covered.

Transition time for Pat's students is quick. It took no more than two minutes for the students to leave their classroom, walk up the steps and get on the computer.

The computer lab contains 20 networked PC computers. Students log in to the computers with a unique ID number assigned by the district. Because of past experience of long page load times and network failure, Pat loaded the contents of the CD-ROM on to the hard drive. This made access to the *ELIFE* content Web pages quicker than using the network itself.

Each student worked on his or her own computer with the exception of two students. One of these was a learning support student who was not comfortable using computers. Pat was unclear why the other girl did not get on her own computer.

It was noted that at least two students had difficulty getting the main idea from the Concept 7.1 animations. Some learners had difficulty interpreting the pictures.

The students spent 21 minutes of actual time on the computer on this day.

At the end of the class, Pat instructed the learners to explain the concept they learned from each ELIFE section in their journals.

Pat did not use the CalorieQuest. It appeared to be too much "back and forth clicking" between multiple browser windows when performing the calculations for her to use comfortably. She did not like the multiple windows feature. She got lost with this form of navigation and is not comfortable enough to use it with students, especially if she would be needed to troubleshoot students. Furthermore, Pat uses the topic of calories when teaching the digestive system and would be more likely to use this activity during that unit.

A novelty effect was observed on this day with regards to the sound effects and animations.

January 14, 2002

Quizzes taken from the previous Friday were passed back. Pat reviewed some of the main problems that learners had understanding:
• Understanding what an equation is – reactants placed on the left side of the arrow and products placed on right side of the arrow. Details of what are "reactants" and "products" are explained.
• The breaking of the phosphate bonds produces energy.
• Role of enzymes in the reaction.
This was presented on the blackboard in a very traditional manner.

After reviewing materials, the students went to the computer lab to continue to use the interactive tutorials.

On one computer, there were problems with altering the font size on one of the browsers. The tech support person could not solve the problem.

Some of the lower level learners had difficulty understanding the Concept 7.4, page 2 ETC animation. Some learners did not comprehend from the previous instruction that ATP is a source of energy

The entire pinball animation, Concept 7.6 was not displayed in the browser window. The learners had to scroll up and down even when the graphic was "zoomed out" entirely on a Windows machine.

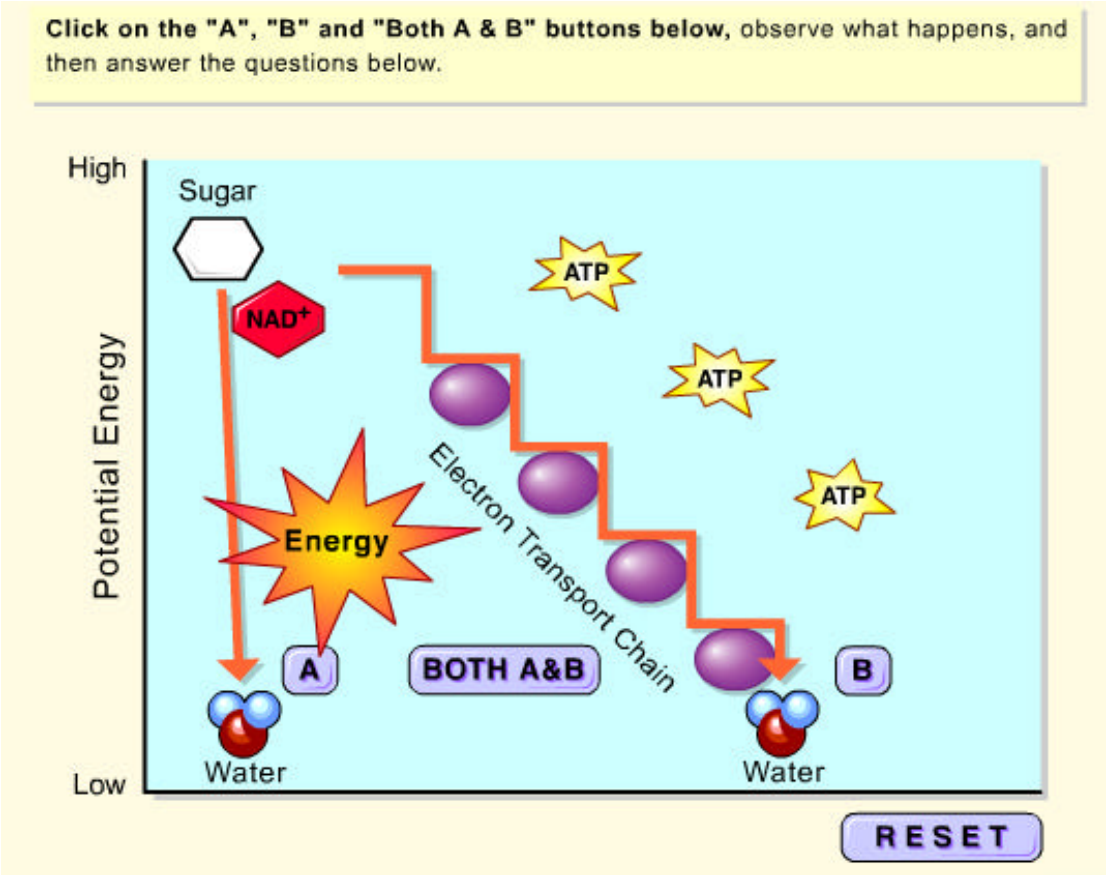
January 15, 2002

A pedagogical shift in Pat's delivery of instruction was noted on this day. Pat had set up a computer and an LCD projector on to a cart to use in her classroom. The *ELIFE* files were loaded onto the computer's hard drive. Assistance was required to adjust the monitor control panel settings to 800 X 600 dpi resolution. The text font also had to be increased. This maximized the image display on the screen.

Pat walked the students through Concepts 7.4 and 7.5. Guiding questions were used throughout to focus students on the processes that occurred in the animations of the two reactive pathways of the electron transport chain and video clips of the Hindenburg. The Cellular Respiration Pinball was used to illustrate the main inputs and outputs of cellular respiration.

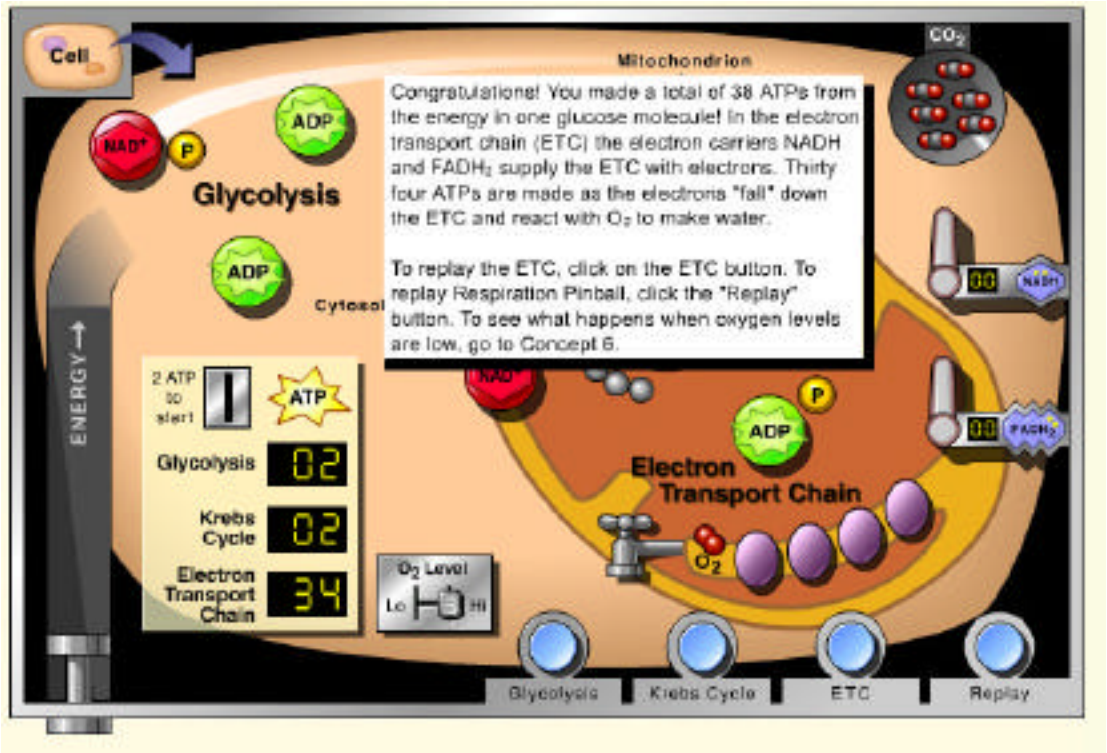
Questioning / Opportunities to respond data:
Questioning / Opportunities to respond is a strategy used to show how engaged the class is and to see if they learners know the content. The researcher used five-minute increments.

Concept 7.4, ETC diagram: 9 questions asked. 9 correct responses. 100% correct responses. Illustrates that the students understand the concept presented in the animation.



Concept 7.5, Respiration Pinball: 4 questions asked. 2 correct responses. 50% correct responses. The learners are not understanding the concept. The animation is very busy with much going on. Many things on the screen are happening at one time.

During instruction, Pat presents the “big picture ideas ” of this interactive animation. For example, she states: “Oxygen captures the electrons and it makes water”. Throughout the instruction, intermediary compounds and specific nomenclature of Kreb’s Cycle is de-emphasized.



January 16, 2002

The computer lab contains an ASK 300 flat panel monitor that is placed on a Dukane projector. Prior to the class, Pat had requested that the tech support person come into the lab to set up the projector interface to the computer. It was not set up after the tech support person came in. After the first period class, the tech support person had to come in again. In order to see the projection on the wall, all lights in the room had to be turned off.

Learners used Concept 8.1. Pat began the class by illustrating concepts using the Dukane projection. Pat illustrated Concept 8.2, page 1 and 2 with the projection. She instructed each student to plot a graph with Concept 8.2, page 2. She modeled the use of the light source. After the students constructed a graph, Pat used guided questions to explain the data patterns.

Next, Pat used the Photosynthesis BioCoach on the Biology Place to present students with an overview of photosynthesis. Learners were instructed to copy the photosynthesis equation on their notes. Learners were then instructed to draw the “big picture” diagram for their notes.

January 29, 2002

Yesterday, students learned about the scientific method. They were given a Globe textbook worksheet to apply what they learned. Pat reviewed the worksheet with them. This set the stage for going through the process of the scientific method for a chromatography lab. Guided questions were used to illicit student ideas on investigating a problem and formulating a hypothesis pertaining to the number of pigments in a leaf.

Even though the Exploring Life Ch. 8 materials contain an interactive animation of the chromatography lab, veteran teachers that are participating in our study implement this lab as a hands-on lab in their classroom. Many have been doing so for years. Pat feels that this is an important lab for the students to do since it emphasizes important processes of biological science.

Pat uses a computer on a cart with an LCD projector to display Concept 8.2, page 3. The teacher read the page and students stated a hypothesis for the lab. The teacher walked through the animation and noted the changes in the experimental procedure that they will employ in tomorrow's class. Pat used the animation to illustrate the process of a solvent moving up a paper along with a pigment.

Pat passed out a handout that the students will use to practice measuring the pigment migration up a piece of chromatography paper. Pat placed an overhead transparency on a screen with a copy of a labeled chromatogram. Students were instructed to measure the solvent distance and then the distance traveled by all three pigments that were labeled. Students had enough time to take only the measurements. They did not set up the relationships for the calculations.

According to Darlene, this lab would not work with these students without prior review and practice of measuring skills prior to implementing the lab. During the measuring activity, approximately 20-25% had difficulty using a ruler to measure. They did not know how to tell the difference between centimeters and millimeters on the ruler. Darlene and Pat had to work with these students individually to help them practice their measuring skills.

Pat presented the sequence of events that would be occurring in the laboratory on the white board. Diagrams with arrows were used to illustrate the movement of the solvent and the pigments.

February 4, 2002

Pat began class by reviewing the equation of photosynthesis on the board. Pat noted that in the next lab, the rate of photosynthesis would be measured using oxygen production. Placing a circle around 6O2 in the photosynthesis equation highlighted this.

Pat displayed Exploring Life, Concept 8.1 page 3 on the screen with an LCD projector device to illustrate a cross section of the leaf. Students were instructed to copy the diagram. On the board, Pat draws an additional diagram and placed labels structures on the diagram. Concept 8.1 page 4 is then shown. Pat used the interactive animation to illustrate areas where there are differences between high and low sugar production. Emphasis is placed on the low sugar production in the air spaces, and the change in sugar production as one moves from the interior leaf air spaces through the stoma out into the epidermis.

Students were then given time to complete their chromatography labs. When I asked fourteen students why the data from different team members was different, ten students did not have an idea, even after we agreed that the leaf and solvent were the same for each student. One student stated that the solvent might have migrated to the top faster on one of the trials and this might have caused the numbers to be different. One student stated that even though the same type of leaf was used, they have different amounts of pigment types in them and this is what caused the differences in pigment migration measures. One student stated that pressing the coin on the leaf with different forces caused the differences. One student noted that different shades of yellow caused one student to have more measurements. It appeared that the students did not think that an error in measurement was the reason for the different measurements. Part II on last Friday's quiz revealed that many students made errors in measurement. It appears that they do not understand that they might have made measurement errors.

February 5, 2002

In preparation for Investigative Lab 8, *Photofinish*, Pat took her students up to the computer lab. She created a handout (*Photosynthesis-Lab*), with fourteen questions to guide students in understanding the prelab materials on the *ELIFE* Website. The first question had students label structures in a similar diagram that was presented in yesterday's lesson (the diagram in Concept 8.1, page 3). It appeared that six students were not taking the task seriously in Period 1. No students were able to complete the last page of the prelab handout.

A new student security log-in kept some of the students from logging into the computer.

February 6, 2002

Pat began class by asking the learners what they would be measuring today. There was no response from the students that indicated they understood the concepts presented in the laboratory prelab procedure. Pat displayed the Photofinish lab procedure with the LCD projector. She walked the students through the entire procedure. It appeared that all students were attentive.

Learners worked in pairs. Four students sat at each lab table. Of the two that I observed closely, one student at each table had an IEP. Each pair collected data for one type of leaf. This was an appropriate way to set up this lab for these learners. One pair of learners conducted the procedure for one leaf, while a second pair of learners conducted procedure for a different leaf. The students had difficulty following the procedure. Darlene had to coach the students to work as a team in which one student would read the procedure and the other student would perform the experimental set-up. These students need to follow directions step-by-step.

Students had much difficulty recording data. They did not understand how to record data on their data table. In most lab groups, only two rows on the data chart were completed. In some cases, the actual time (i.e. 9:34) was written instead of minutes in the "Time in minutes" column.

After a discussion with Darlene and Lana, it was recommended that Pat should read the procedure step-by-step from the lab procedure handout while displaying the animations with the LCD projector. In period 3, Pat implemented these recommendations. She walked the students through the procedure with the animations. Most students were attentive and two students asked questions pertaining to the procedure. Pat also drew a sample data table on the board and modeled how to record the data. Pat also had learners pay particular attention to key text in the procedure and instructed them to underline certain phrases.

The students enjoyed the lab. They were in interested in it.
In period 3, all but 3 students responded that the lab was interesting.
Comments from the students included:
"It was fun."
"It was interesting."
"It was interesting to see the gas coming out of the leaves."

The idea of using this lab as a "race" helped motivate the non-motivated learners in this class.

February 12, 2002

Period 1:
Students are at lab tables with their *Photofinish* lab. Pat asked each group to report how many leaf disks rose to the top in four minutes. Data was tallied on the white board. Pat asked students to examine the data to see who the winner was. Pat read questions 1 and 4 to the class. The students were instructed to complete the lab worksheet through question 6. The students moved back to their seats after they completed the first six questions.

Once all students had returned to their seats, Pat asked them if they could think of anything that might have affected why different groups had different results. Pat listed their answers on the board:

Amount of light
Size of disk
Touching leaf
Small vs. large leaf

Pat stated a new problem: “Does the light effect the rate of photosynthesis?”

A student stated a hypothesis: “If there is more light, then the disks will rise faster.” Pat writes this on the board and students were instructed to copy it down on their worksheet for question 7.

Pat asks them how they would set up an experiment to test this hypothesis.
Jess: “Use different Watt light bulbs.”

Michelle: “How close. Move the light different distances. If it’s closer, it will get more light.” Pat writes this on the board.

Pat: “What things in the experiment will make the leaf float more?”
Student: “Number of chloroplasts.”
Pat: “How would we find that out?”
Student: “Through a microscope.”

Pat: “Would temperature affect it?”
Pat calls on Jess to respond.
Pat: “How do you know that when you heat something it will expand?”
Students have difficulty articulating this.
Pat describes cement cracks on the road expanding as an example.

Pat: “There may be other factors that affect the leaf. Can you write these down please. We said temperature and the number of chloroplasts. How about the thickness of the leaf?”

Pat: “What the first thing we should do?”
Student: “State a problem.”

Pat instructed the students to write the problem in the *Extension* space of the lab worksheet. She wrote this on the board. Next, Pat restated the hypothesis and wrote it on the board:
Hypothesis: If there is more light, then the disks will rise faster.

Pat stated: “Next we have to list the procedure. What do we need to do first?” A student replied and it was written on the board. “What next?” Another reply and then it was written on the board. Four steps of the procedure were written and then the bell rings.

Period 3 was similar to Period 1:
Students articulated three different problems for question 7:

1. Different light bulbs.
2. Distance from light.
3. Rotating syringe.

Much more prompting had to be used with these students compared to Period 1.
For question 8, a student noted that the same experimental set-up could be used as the lab. Pat agreed.

Question 9 was discussed. Two factors were mentioned: temperature and if the leafs had holds.

Pat next modeled the Extension with the same example from period 1.
It appeared that five students were not following Pat – they were either not writing anything on their paper or they did not have their paper in front of them. Two students were moved to the back table for disciplinary reasons.

During the procedure steps, one student made a point to develop an operational definition of "counting".

Pat passed out the *Exploring Photosynthesis Lab Test*. Pat pointed out the rubric to the students. Students were informed that they would develop an experiment and carry it out.

Pat: "Can we make our question more focused?"
Student: "Yes."
Pat mentions comparing 40, 80 and 100 watt light bulbs.
Bell rings.

February 13, 2002

Period 1: Pat continued with the procedure from the previous day's lesson. Emphasis was placed on how data would be collected. Students came up with two different ways that data could be measured:

Time for each disk to rise
Or
Every ___ minutes count disks which rise

Students were polled and it was decided that it would be best to measure the "time for each disk to rise".

Pat handed out the *Exploring Photosynthesis Lab Test*. Instructions were read. Pat informed the students that they would not be able to choose certain variables to test.

Students completed Photosynthesis Lab Test, Part I in lab groups of four. Sections include:
Questions

Identification of variables
Materials
Procedure
Data Collection & Presentation

Pat decided it was important that students completed this part in larger groups of 4 instead of groups of two or individually. Pat's rationale for grouping students this way was to enable them to work together and engage in discourse to work through problems that they had. Pat noted that if learners did this activity in groups of two or individually, then she and Darlene would be spending too much time answering individual questions and the students would not be able to complete the activity.

Both Darlene and I observed in each class that one student at each lab table appeared to be the leader of the task and would work through the thought process. It appeared that the other members of the group were not active participants.

Pat asked Loren to review one of his group member's write up and critique it using the rubric.

<u>February 14, 2002</u>

Students conducted the experiments in groups of four. One group had a difficult time getting started. One of the group members said, "We need Greg here." It appeared that Greg was their "group leader" yesterday and he was not present today.

The group testing the temperature variable did not think through testing at different temperatures. Pat had to work with this group.

It appears that the groups did not read through the procedures that they wrote the previous day.

When I questioned the group that cut leaves into squares to compare with circular shapes, they believed that the circles would win the race based on aerodynamic shape. They were not able to articulate knowledge of factors that affect the rate of photosynthesis.

The group testing the amount of bicarbonate could not articulate why the syringe with the larger amount of bicarbonate solution won the race.

One member of the group testing temperature state that heat makes things move faster.
Al: "What things?"
Student: "Molecules."
Al: "Molecules in what?"
Student: "Chlorophyll."
When I prompted students to think about other things that might be moving with three guiding questions, one student replied "the bicartbonate solution."

I used further questioning strategies to have the learners articulate their perceived connections between the bicarbonate solution and the process of photosynthesis. After much questioning, the students were able to articulate their conception of how temperature affects photosynthesis.

It appears that these students can understand the processes and relate them to the concepts, but they require much guidance and structure. This was substantiated in Period 3. Each group was able to articulate their understanding of the process of photosynthesis to me as it relates to their experimental design. Prompting questions had to be used to get the learners to make their thinking visible.

Period 3: At 9:25, Pat called the students' attention to look at their experimental procedure they had written.

Pat told me that she is very glad to do this lab practical with these students. She noted that the students were comfortable with going to the lab tables and getting right to work since they were familiar with the lab having done a related procedure before.

Additional Notes:

Academic engagement: Academic engaged time (recorded on-task/off-task behavior of selected students for 15-minute intervals) was 41.9% when students were using the information-seeking, guided question sheet with the Exploring Life program. Academic engaged time was 87.9% when Pat included more direct teaching with students' use of the Exploring Life program. (e.g., Pat used an advance organizer, guided students through examples, modeled how to find information, etc.). This is very high. Ideally you want something around 90%.

Conception of teaching science with the Internet: When given with the following post field-test survey question:
How has your conception of teaching science with the Internet changed since you began using the Exploring Life materials? How? Why?
Pat responded:
"The correlation of the computer, text, and labs have helped me to provide better laboratory experiences for my Applied students. Before Exploring Life I had a great deal of difficulty demonstrating all the steps in a procedure. With this program, my students can revisit the procedure as often as they like. The display of what to look for in the experiment made them more confident. These lower ability students did generate an experiment and became involved in the course work. The computer graphics are a big help to these students."

Fastplants Lab: These students only have 42-46 minute classes. The honors students took the entire class period to set up the Fastplants lab and get the first two readings. The second class period continued the readings. Pat noted that the second period honors

students had difficulty understanding what was going on since they did not perform the experimental set-up.
During the first week of observations, Pat informed me that the applied students would not perform the experimental set-up for this lab. They would only gather the data so the experiment can be done with in a class period. Weeks later, after completing the chromatography lab, she decided that this lab would be difficult for her applied students to comprehend. Furthermore, it was noted that a very large time commitment would be necessary for her *applied* biology students to complete this lab.

Photofinish lab:
• Pat used ivy plants and kept then under lights for a few days before. The results were fast. The disks were rising within two minutes.
• The idea of using this lab as a "race" helped motivate the non-motivated learners in this class.

Photofinish lab practical: Be sure to include the lab practical in the *ELIFE* materials. This activity with the assessment is directly in line with what was stated in the NSF proposal: *ELIFE* will contain authentic assessments that include rubrics.

Refer back to previously introduced concepts in the chapter: Materials in the chapter, i.e. online concepts, need to refer back to previously introduced concepts and ideas. This will help learners make better connections to previously introduced concepts. For example, the ChocolateQuest that is introduced at the beginning of the chapter is never referred to again in any other chapter 8 activities or the lab. Helping learners to continuously cycle back to previously introduced concepts will help the learners understand the content and concepts presented in the chapter.

Availability of technology:
• Prior to pilot testing, Pat had set up her classroom with five iMacs and two 225 Mhz Performas, each on their own rolling carts. The rolling carts were hard plastic lab carts; these were not designed for a computer. The iMacs contained 64 MB of RAM and ran system 8.6. The processor speed could not be located, but it appeared to be a 300 MHz iMac. Each iMac was connected to a Farallon Ethernet hub that contained eight ports. In this configuration, students would sit in groups of 2 and 3 with each computer. When trying to use the *ELIFE* materials with this configuration, she experienced the IE browser was launching multiple windows on the iMacs. She also reported additional problems with the computers and decided that it would not be wise to attempt to implement the materials with this set-up.

• After the second observation day, Pat and I had a detailed discussion about setting up her classroom to teach with one-computer and an LCD projector. Pat has never taught this way before in her classroom. In our discussion, she noted that the school had three LCD projectors and it was very difficult to check one out. It was noted that the science department chair was in possession of one of the projectors and in the past he has been very reluctant to lend out projector. I recommended that Pat go through the proper protocols to borrow an LCD projector. She first went to the media center and was told to

talk to the science department head. After a discussion with the science department head, Pat was able to borrow an LCD projector. She placed it on a mobile cart along with her computer's hard drive. The image was projected onto the whiteboard located in the front of the classroom. She was able to continue to use this equipment for the remainder of the field-testing. During the post implementation interview, she noted that the school recently obtained two more LCD projectors for teacher use.

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 have minimum software and hardware requirements. In this school, there appears to be a communication problem between the classroom teachers and the district support people. A common language is not understood between these folks. It seems that the classroom teachers do not know the right questions to ask. This has been reported in personal e-mail correspondences from other EL participants.

Perceptions of special education teacher: The special education teacher and the instructional aides for learning support students think highly of the *ELIFE* Web materials. They view the use of the visualizations as a major benefit of the program. Furthermore, they noted that accessibility on the Web allows for the students to use the materials at other times outside of the class. Darlene noted that a major benefit of the *ELIFE* program was that it gave her the opportunity to work with the content ahead of time. This enabled her to have a more active role as a co-instructor in these inclusive science classrooms.

Perceived use of technology: As a result of using the *ELIFE* materials, both Pat and Darlene "see potential for higher implementation of technology integration" in the biology classroom.

Need for structure: Prior to beginning an inquiry-based lab, the students should be presented with an advanced organizer on the stages of an inquiry (or components of an investigative laboratory). According to both Lana and Darlene, the students get lost in the process since an inquiry has many different parts. They need to be able to see "the big picture" to see where they are going.

*Use of worksheets***:** During this field test, we once again have observed a teacher create worksheets as an accountability measure. When *ELIFE* is used in this context, the worksheet becomes an exercise in information seeking and not understanding.

Locus of control/discipline battles: Lana and I agree that Pat does not chose to fight the "management battles" of students being on-task in the computer lab as much as she does in her own classroom. This could be a good rational for having laptops in the classroom. This would increase the comfort level of the teachers using technology. Pat agreed with this when we discussed the issue of locus of control. Pat concurred with our observations that she fights more management battles in her classroom than in her computer lab. She is more comfortable in her own classroom. In the computer lab, she chooses not to fight the discipline battles.

Teaching inquiry skills: Teaching inquiry skills takes time with lower level students. Taking time out of a "standards-based" curriculum to teach inquiry skills will most likely be a challenge to implement in school districts where there is much emphasis placed on a high-stakes test, unless the high-stakes test truly assesses students' comprehension of the inquiry process.

Implementation without relying on the textbook: Data from the field observations illustrated that the Exploring Life program can be implemented successfully in classrooms with low ability students without a reliance on the textbook.

Recommendations for developers:

- In the teacher's materials, it should be recommended that the teacher use a one-computer with a projection device to show the animation in an "interactive lecture" format. This will enable the teacher to show the "big picture" to help learners understand the concepts.

- In the teacher's materials, A note to teachers should be included to test out the computer's audio level.

- Some of the lower level learners had difficulty understanding the Concept 7.4, page 2 ETC animation. Some learners did not comprehend from the previous instruction that ATP is a source of energy. I would recommend that a sentence be included in the paragraph above the animation that reminds students about the role of ATP as an energy-carrying molecule.

- The entire pinball animation, Concept 7.6 was not displayed in the browser window. The learners had to scroll up and down even when the graphic was "zoomed out" entirely on a Windows machine. The developers need to look at a variety of screen size resolutions to recommend an optimal setting for the monitors to display the graphic. Furthermore, it might make sense to recommend a minimum screen size setting of 800 X 600 pixels and make sure that each future animation with a large graphic is designed to be viewed within a framed environment of a 15" monitor screen with a resolution of 800 x 600 pixels.

- In prelab and laboratory handouts, altering the font type and size to emphasize key procedural items might assist the students in understanding the procedure better.

- Although the Website contains excellent animations to assist learners in setting up procedures, many teachers will not have computer access in their classroom to show these to the students. Inserting diagrams that illustrate procedural lab steps as often as possible will help these learners with their experimental set-up.

- In the *Photofinish lab*, a sample completed data chart needs to be included in the procedures placed before Data Table 8.1. This would present the learners with a concrete example on how to properly record data during their experiment.