

WBI – Web-based Inquiry for Learning Science Analysis Report for Exploring Life Pilot Materials

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Recent science education reform initiatives (American Association for the Advancement of Science, 1993; NRC, 1996) emphasize using inquiry-based teaching to help students learn science. According to the *National Science Education Standards*, **inquiry** refers to the diverse ways in which scientists study the natural world and propose explanations based on evidence. Trowbridge, Bybee, and Powell (2000) contended, however, that drawing conclusions may be as valid a form of scientific inquiry as formulating explanations. They suggested that scientific inquiry should consist of asking questions, formulating hypotheses, designing experiments, gathering and analyzing data, and drawing conclusions.

The World Wide Web offers activities that provide opportunities to learn science through inquiry-based activities. Just like classroom-based science inquiry activities, Web-based inquiry activities (WBIs) for learning science fall along a continuum from **learner-directed** to **materials-directed**. Learner-directed activities tend to focus on individual decisions and much learner involvement in making decisions on how to complete the inquiry. Materials-directed inquiries tend to be very specific about what learners should do in order to complete the inquiry and often lead the learner towards expected conclusions and explanations. The purpose of this evaluation report is to:

1. Identify the Exploring Life prototype material that can be described as Web-based inquiry activities (WBIs) for learning science.
2. Describe how these activities fall across a continuum from learner-directed to materials-directed.

In order for an activity on a Website to qualify as a science WBI, it must meet all six criteria listed in Table 1. Eight Exploring Life activities developed for chapters 7, 8, and 36 qualified as a science WBI. These activities were:

- Ch. 7 Webquest - CalorieQuest
- Ch.7 Laboratory 7.1 Investigating Chemical Energy Stored in Food
- Ch.7 Laboratory 7.2 Guided Research: Cellular Respiration in FastPlants®
- Ch.7 Explore!: Aerobic Exercise and Dietary Supplements
- Ch. 8 Webquest - ChocolateQuest
- Ch. 8 Laboratory 8.1 Photo Finish
- Ch. 36 Webquest - ThermalventQuest
- Ch. 36 Investigative Lab - You Are a Pond Organism

The WBI manual and instrument - Beta Version 1 (Appendix 1) developed by Drs. Bodzin and Cates of the evaluation team was used to analyze each Web-based activity that met the WBI qualification criteria. While individual teachers may hold different opinions about the desirability of the positions along this continuum, the instrument is neutral. That is, it classifies where the activity falls, rather than make a value judgment about the desirability of that position on the continuum. The manual provides guidelines for how to use an instrument designed to classify science WBIs on the World Wide Web.

Table 1. WBI Qualification Criteria

Criteria	Title	Descriptor
1	Three Inquiry Essentials	<p>A WBI must contain at least the first three essential features of classroom inquiry described in <i>Inquiry and the National Science Education Standards</i>:</p> <ol style="list-style-type: none"> 1. Learners are engaged by scientifically oriented questions that are stated explicitly or implied as a task. 2. Learners give priority to evidence, which allows them to draw conclusions and/or develop and evaluate explanations that address scientifically oriented questions. 3. Learners draw conclusions and/or formulate explanations from evidence to address scientifically oriented questions.
2	Learner Centered	The WBI should be phrased in such a way that learners would perceive it as directed at them. The majority of the wording used in the WBI should be directed at the learner (you), not at the teacher (your students).
3	Student Learning Science Concept or Content	The WBI must support student learning of a science concept or science content. Science WBIs must fall into a recognized science discipline (biology, chemistry, physics, environmental sciences, astronomy, oceanography, and the like).
4	Web-Based	The WBI must be Web-based. A WBI is more than reformatted text from printed sheets placed on the Web, describing how an inquiry activity may be completed. Instead, it should be enhanced or customized to take advantage of the features of the Web to deliver instruction.
5	Scientific Evidence	Evidence used in a WBI should be of the same type an actual scientist would use.
6	Conclusions or Explanations Involve Reasoning	Conclusions and/or explanations in WBIs should be more than simple data analysis and reporting. They must involve reasoning .

Twenty-nine teachers participated in this evaluation activity. A science educator member of the evaluation team spent forty-five minutes with the teachers providing content background on inquiry and the National Science Education Standards and reviewing procedures for completing the instrument.

Twelve teams of 2-3 classroom biology teachers reviewed the Exploring Life WBIs. Teachers during the Lehigh 2001 summer evaluation workshops. Each WBI was reviewed by either three or four teams of teachers (see Table 2). Each team examined two or three Exploring Life WBIs using a multi-pass unanimous consensus approach (100% agreement among the teachers on the classification of each WBI). As a second validation, each team justified their placements to a science educator member of the evaluation team. This is a variation of content analysis, a research technique for making

replicable and valid inferences from data to their context (Krippendorff, 1980). Such analysis does not necessarily describe the actual experiences learners have, however, but rather the opportunities for learning the instructional materials offer (Tamir, 1985). Content analysis has been used in previous research studies to evaluate high school laboratory manuals to determine how well they promote the basic and integrated science process skills that are involved in scientific inquiry (see for instance, Germann, Haskins & Auls, 1996; Lumpe & Scharmann, 1991; Tamir & Lunetta, 1978, 1981).

Table 2. WBIs reviewed

Reviewed Activity	Team of teachers
Ch. 7 Webquest - CalorieQuest	4
Ch.7 Laboratory 7.1 Investigating Chemical Energy Stored in Food	4
Ch.7 Laboratory 7.2 Guided Research: Cellular Respiration in FastPlants®	4
Ch.7 Explore!: Aerobic Exercise and Dietary Supplements	4
Ch. 8 Webquest - ChocolateQuest	3
Ch. 8 Laboratory 8.1 Photo Finish	3
Ch. 36 Webquest - ThermalventQuest	4
Ch. 36 Investigative Lab - You Are a Pond Organism	3

The placement of each activity on the final instrument is provided on Table 3.

	Learner Directed		Materials Directed	
Essential Feature of Inquiry	L2	L1	M1	M2
Learners are engaged by scientifically oriented questions.	<p>Prompts learner to formulate own question or hypothesis to be tested.</p> <p>Laboratory 7.2 Guided Research: Cellular Respiration in FastPlants^α</p>	<p>Suggests topic areas or provides samples to help learner formulate own question or hypothesis.</p> <p>Laboratory 7.2 Guided Research: Cellular Respiration in FastPlants^α</p> <p>Laboratory 8.1 Photo Finish</p>	<p>Offers learner lists of questions or hypotheses from which to select.</p> <p>Laboratory 7.2 Guided Research: Cellular Respiration in FastPlants^α</p>	<p>Provides learner with specific stated (or implied) question/hypothesis to be investigated.</p> <p>Webquest — CalorieQuest</p> <p>Webquest — ChocolateQuest</p> <p>Webquest - ThermalventQuest</p> <p>Laboratory 7.1 Investigating Chemical Energy Stored in Food</p> <p>Laboratory 7.2 Guided Research: Cellular Respiration in FastPlants^α</p> <p>Laboratory 8.1 Photo Finish Investigative Lab 36 - You are a Pond Organism</p> <p>Explore!: Aerobic Exercise and Dietary Supplements</p>
Learners give priority to evidence, which allows them to draw conclusions and/or develop and evaluate explanations that address scientifically oriented questions.	<p>Learner determines what constitutes evidence and develops procedures and protocols for gathering relevant data (as appropriate).</p> <p>Laboratory 7.1 Investigating Chemical Energy Stored in Food</p> <p>Laboratory 7.2 Guided Research: Cellular Respiration in FastPlants^α</p> <p>Laboratory 8.1 Photo Finish</p>	<p>Directs learner to collect certain data, or only provides portion of needed data. Often provides protocols for data collection.</p> <p>Laboratory 7.1 Investigating Chemical Energy Stored in Food</p> <p>Laboratory 7.2 Guided Research: Cellular Respiration in FastPlants^α</p> <p>Laboratory 8.1 Photo Finish Investigative Lab 36 - You Are a Pond Organism</p>	<p>Provides data and asks learner to analyze.</p> <p>Explore!: Aerobic Exercise and Dietary Supplements</p> <p>Ch. 8 Webquest — ChocolateQuest</p>	<p>Provides data and gives specific direction on how data to be analyzed.</p> <p>Ch. 7 Webquest — CalorieQuest</p> <p>Ch. 8 Webquest — ChocolateQuest</p> <p>Ch. 36 Webquest - ThermalventQuest</p>

<p>Learners formulate conclusions / explanations from evidence to address scientifically oriented questions.</p>	<p>Prompts learner to analyze evidence (often in the form of data) and formulate own conclusions/explanations.</p> <p>Laboratory 7.2 Guided Research: Cellular Respiration in FastPlants^α</p> <p>Explore!: Aerobic Exercise and Dietary Supplements</p>		<p>Prompts learner to think about how evidence leads to conclusions/explanations, but does not cite specific evidence.</p> <p>Explore!: Aerobic Exercise and Dietary Supplements</p>	<p>Directs learner attention (often through questions) to specific pieces of evidence (often in the form of data) to draw conclusions and/or formulate explanations.</p> <p>Webquest — CalorieQuest Webquest - ThermalventQuest Laboratory 7.2 Guided Research: Cellular Respiration in FastPlants^α Laboratory 8.1 Photo Finish Investigative Lab36 - You Are a Pond Organism Ch.7 Explore!: Aerobic Exercise and Dietary Supplements</p>		<p>Directs learner attention (often through questions) to specific pieces of evidence (often in the form of data) to lead learner to predetermined correct conclusion/explanation (verification).</p> <p>Webquest — ChocolateQuest Webquest — ThermalventQuest Laboratory 7.1 Investigating Chemical Energy Stored in Food Ch.7 Explore!: Aerobic Exercise and Dietary Supplements</p>		
<p>Learners evaluate their conclusions / explanations in light of alternative conclusions/ explanations, particularly those reflecting scientific understanding.</p>		<p>Prompts learner to examine other resources and make connections to conclusions and/or explanations independently (Catalyst).</p> <p>Webquest - ThermalventQuest Laboratory 8.1 Photo Finish</p>	<p>Provides hypertext links but does not refer to them. Learner independently examines other resources and make connections to conclusions and/or explanations.</p>	<p>Directs learner to hypertext links related to areas and sources of scientific knowledge.</p> <p>Explore!: Aerobic Exercise and Dietary Supplements</p>	<p>Identifies areas and sources of scientific knowledge that could be useful, but does not provide hypertext links.</p>	<p>Suggests or implies possible connections, but does not provide hypertext links.</p>	<p>Explicitly states specific connections, but does not provide hypertext links.</p>	

Learners communicate and justify their proposed conclusions / explanations.	Reminds learner of general purpose of communication and/or need for communication, but gives no specific guidance.	Talks about how to improve communication, but does not suggest content or layout.	Suggests possible content to include and/or layout that might be used. Laboratory 7.2 Guided Research: Cellular Respiration in FastPlants²	Specifies content to be included and/or layout to be used. Explore!: Aerobic Exercise Dietary Supplements
	Learner-driven with much initiative and independence.	Learner makes decisions, but with support and scaffolding, particularly with the process.	Learner does much selecting from provided materials. Limited choices.	Materials-driven. Learner makes choices and is given much direction.

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Findings

Webquests

Webquests are short, fun activities that engage students in the chapter subjects before they have even learned the key concepts. In general, 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 provides for an appropriate design if the instructional goal is to have the learner complete the activity within one classroom period.

Each reviewed Webquest is described below.

Chapter 7 Webquest - CalorieQuest

Ch. 7 Webquest was classified as a partial inquiry that provides learners with an implied question to examine the relationship between food calories and maintaining an appropriate weight (M2 in the *Questions* row). Learners are provided data to be analyzed using hyperlinks to an external Website. Specific direction on how data is to be analyzed is provided (M2 in the *Evidence* row):

Go to [Food Finder](#) and select Burger King from the pull-down menu next to "Which restaurant do you want to search". For "What item do you want to search for", type in "chicken salad" for Yung. Leave the other fields in the table blank and click "Fire Up the Deep Fryer." Record the number of calories in the table below. Repeat this procedure for each item in Yung and Tom's lunch and record your findings in the table.

Learners are directed to a text reading on an external Website to assist in formulating a conclusion (M1 in the *Conclusions/Explanations* row).

Read [Diet and Nutrition](#) and describe what you would recommend to both Yung and Tom in order to keep their ideal weights.

The following are selected comments/recommendations from the teachers and the program evaluator:

- **Reword: 2.** *Think about why their caloric needs are so similar when they have such different lifestyles and weights.* to “Why do you think their caloric needs are so similar when they have such different lifestyles and weights?” Provide a text box for learners to write down their ideas.
- Encourage learners to justify their responses to question #6. Add the following text: “Justify your selection.” This will help make the learner’s thinking visible to the teacher.
- Format another table in #4 so students can itemize their meal as in #3.

Chapter 8 Webquest - ChocolateQuest

The Chapter 8 Webquest was classified as a partial inquiry. Learners are presented with a specific question to be investigated (M2 in the *Questions row*): *how is this bean made?* A series of questions is provided to guide learners in their analysis of digital images on external Websites (M2 in the *Evidence row*). Learners are presented with a diagram of the reactants and products of photosynthesis and are then directed through a series of questions to a predetermined explanation (M2 in the *Concluions/Explanations row*). Question 2d: *How do you think that the Theobroma tree gets the energy to build these pods and seeds?* may serve as a cognitive prompt. However, the answer is provided in the sentence below the text box, thus short-circuiting the inquiry.

The following are selected comments/recommendations from the teachers and the program evaluator:

- Good organization and flow from grabbing the interest with chocolate to photosynthesis and bringing the topics together in the final question.

Chapter 36 Webquest

The Chapter 36 Webquest was classified as a partial inquiry. Learners are provided with an implied question to be investigated (M2 in the *Questions row*): *Imagine what kind of life can survive here.* Learners are guided through a virtual exploration of a hydrothermal vent through the use of questions and hypertext links to external Websites. Data is provided at the external Websites. Different degrees of material direction is provided in this activity (M1 and M2 in the *Evidence row*). #2 is an M1 example: *Take a look inside the vent. Record your initial observations.* The structured chart in #3 is an M2 example.

Learners are directed with questions to external Websites that lead learners to predetermined explanations (M2 in the *Concluions/Explanations row*):
c. Plants use sunlight to convert CO₂ and water into carbohydrates, a source of food, but there is no sun present for the bacteria in the hydrothermal vents. How do the vents provide food for the tubeworm? For more information, look up the definition of [chemosynthesis](#).

Learners are prompted to examine other resources to make additional connections to their explanation (*L2 in the Alternative Explanations/ Conclusions row*):
Can you think of some of Earth's other extreme environments? Describe some of the unusual factors and how they influence the life that exists in the environment.

The following are selected comments/recommendations from the teachers and the program evaluator:

- Sparks interest in many areas like substances, worms, thermalvents, chemosynthesis.
- Use of many Webpages to integrate informative gives much value to the Internet for the student.

- On page 1 of the activity, give students a chance to imagine, look at pictures, and ask them to write or describe their ideas.

Laboratories

In general, the laboratories provide learners with a question to investigate. The materials provide protocols for data collection and also provide learners with 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. Only the guided inquiry lab had learners communicate and justify their proposed conclusions/explanations. No laboratories were classified as full inquiries.

Each reviewed laboratory is described below.

Laboratory 7.1- Investigating Chemical Energy Stored in Food

Laboratory 7. 1 provides the learner with explicitly stated questions to be investigated (M2 in the *Questions* row):

Questions: *What is the calorie content of a peanut? How does this calorie content compare to other foods?*

Learners are instructed to design an experiment (L2 in the *Evidence* row):

Design an Experiment: *Using this definition as a starting point, think about how you would design an experiment to find the calorie content of a peanut. What materials would you need? What procedure would you follow? Write a brief outline of your experiment in the box below. Include:*

- * *How you would get the peanut to burn.*
- * *How you would measure the heat.*
- * *How you would trap the heat so it only heats the water.*
- * *What your calorimeter (a device scientists use to measure food calories) would look like.*

When you have completed your experiment outline, print out this page and submit it to your teacher.

The learner is then informed that they “will compare the experiment that you designed to a lab that has been developed by science teachers.” The remainder of the lab provides protocols and a data chart for the learner to record and submit data (L1 in the *Evidence* row). A series of questions is provided to guide learners to specific pieces of evidence to verify predetermined conclusions (M2 in the *Concluions/Explanations* row).

The following are selected comments/recommendations from the teachers and the program evaluator:

- The “Design Experiment” may be quite difficult or overwhelming for lower level learners.
- Learners should conduct their own experiments and then do the class one, so they can compare results!! We see their own experimental process as being more valuable than the “cookbook” one provided.
- The procedure and Table 1 do not direct students to try more than one type of food. Questions 5b and 5c ask students to compare food types.
- The picture of the calorimeter provided in the textbook (Chapter 7, Page 7) completely defeats design process because it gives the design away!!

Laboratory 7.2- Guided Research: Cellular Respiration in FastPlants®

This laboratory is a two-part lab. The first part is a partial inquiry that consist of the first three essential features of inquiry. Learners are provided two questions to investigate (M2 in the *Questions row*):

How fast does respiration occur? How can an organism's respiration be measured?

Learners are provided with a detailed procedure for setting up a complex apparatus for data collection. Learners are then directed to collect specific data with a lab protocol (L1 in the *Evidence row*). The “Analysis” section guides learners to analyze a graph to determine the rate of respiration (M1 in the *Conclusions/Explanations row*).

The “Conclusions” section of Part I prompts learners to formulate their own questions to be investigated in Part II of the laboratory (L2 in the *Questions row*):

Enter two questions into your lab notebook (about germinating seeds and cellular respiration) that you could investigate further. These questions will serve as a starting point for developing your own investigation in the next section.

This prompt is restated again at the beginning of Part II of the lab.

After learners are prompted to review their lab techniques, they are offered suggested topic areas to help formulate their own question or they may develop their own question to investigate (L1 and L2 in the *Questions row*):

Your questions might focus on the seeds themselves, the environmental conditions, or something else altogether — it's up to you!

The second part of the lab is a partial inquiry that consists of four of the five essential features of inquiry.

Students are provided with much scaffolding to assist them in formulating their research question:

Trying to arrive at the right question asked in the right way is often a barrier to someone doing their own scientific inquiry. A good question for scientific inquiry is asked in a way

that actually suggests how the question can be answered. A good question is also one that is focused enough to investigate. The next couple of pages should help you chose a good question for cellular respiration research.

A table of variables is provided to assist learners in generating their questions. (L1 in the *Questions* row)

“Look them over and think of related questions that you could research. Enter your two best questions into your laboratory notebook. Make sure that they qualify as "good questions."

Five questions to investigate are then provided to use if the learner has difficulty formulating his or her own question (M1 in the *Questions* row).

An example of how to formulate a hypothesis that states the relationship between two variables with an "If... then" format, is provided.

A “developing and implementing your plan” section allows the learner to develop procedures for gathering data (L2 in the *Evidence* row).

The activity states that learners will communicate the results of their work. It is inferred that conclusions and / or explanations would be formulated from the data (L2 in the *Conclusions/Explanations* row). A mini-poster format will be used to communicate the experimental findings (L2 in *Communicate* row):

They communicate the final results of their work to others a number of ways. They may publish an article or make a presentation at a meeting. To keep others informed about work that is just getting started biologists often use a form of presentation known as a poster. To report your investigation you will need to prepare a mini-poster. Here is an example:

The following are selected comments/recommendations from the teachers and the program evaluator:

- This activity provides multiple ways of engaging learners with scientifically oriented questions. This is a very appropriate way to structure an activity to accommodate different learner academic ability levels and differences in experiences with inquiry.
- Including a statement in Part II that prompts learners to examine other resources to make connections to the experimental conclusions would transform this activity into a full inquire by providing learners opportunities to evaluate their findings in light of alternative explanations. Hypertext links to related areas of scientific knowledge could be provided.
- Many teachers reviewing this activity noted that this experiment is at a much higher level that is appropriate for their basic biology students.

- It was noted by reviewing teachers that a significant amount of time would need to be invested to complete this lab. One group noted: “This lab is going to take me at least a month.”
- On page 7 in the “Developing and implementing our plan section”, it is recommended that an additional text box be included that students complete to describe what data will be collected and how it will be analyzed.

Investigative Lab 8 Photo Finish

Note: The version originally reviewed with the instrument in Summer 2001 was titled Laboratory 8.1, and compared three types of ivy leaves. Since revisions have been made since the original analysis, instrument placements were validated again and described below using the revised lab that compares two ivy plants.

Learners are provided a question to investigate (M2 in the *Questions* row):

Question: Which will photosynthesize at a faster rate, a young ivy leaf or an older ivy leaf?

An analogy of a foot race is provided to provide a motivating context for the lab. A step-by-step laboratory procedure is provided. Animations are used to model the experimental set up. A data table is provided for the students to record their data (L1 in the *Evidence* row). Learners are instructed to calculate their rate of photosynthesis and compare their rates with other groups in the classroom.

Question 6 directs the learner’s attention to their understanding of plants and photosynthesis to formulate an explanation (M1 in the *Conclusions/Explanations* row):

If the results were not as you predicted, write down at least one possible reason to explain the different rates of photosynthesis you observed. Use your understanding of plants and photosynthesis in your answer.

Question 9 prompts learners to think about alternative explanations (L2 in the *Alternative conclusions/ explanations* row):

What other factors (besides rate of photosynthesis) may be involved in the ability of the leaf disks to float to the top?

The last part of question 6 prompts learners to formulate a new question. A sample is provided (L1 in the *Questions* row). Question 8 requires learners to describe an experimental set-up to test the newly formulated hypothesis. This is developed further in the *Extension* in which learners are instructed to develop a procedure for testing their revised hypothesis (L2 in the *Evidence* row).

The following are selected comments/recommendations from the teachers and the program evaluator:

- The intent of Question 9 is to prompt learners to think about alternative explanations that will lead to formulating a new hypothesis. This question would

be more appropriately placed between the two existing sub-questions of Question #6.

- Question 8 is not written correctly: *Describe how you would set up the experiment to test your revised questions hypothesis.*
Recommend deleting the words “revised questions”. This will flow better since learners are instructed to propose a hypothesis to test in the preceding question.
- The reviewing teachers do not see the *Extension* section as a part of this lab activity. It was viewed as an “add-on”.
- The *Exploring Photosynthesis Lab Test* that is being used by some of the NSF pilot-testers builds on the ideas presented in the extension. It is recommended that this assessment be included as this laboratory’s extension. This would be value-added to the materials since it would provide the learners with an opportunity to engage in a learner-directed inquiry that would be authentically assessed with a rubric.
- For Question #6’s first sub-question, you may want to consider including a hyperlink to other resources either within the Chapter 8 materials to help remind learners of their prior knowledge of photosynthesis. This would assist lower level learners in their thinking.

Investigative Lab 36 - You Are A Pond Organism

Learners are provided a question to investigate (M2 in the *Questions row*):

Question: What is the effect of a change in temperature or the amount of light on a pond ecosystem?

Prelab questions are used to prompt students to think about how abiotic factors (temperature and light) affect heterotrophs and autotrophs in a pond ecosystem. Procedures and directed questions in Chapters 1, 2, and 3 direct learners to collect data (L1 in the *Evidence row*). Questions in all three chapters direct learners’ attention to specific pieces of evidence to assist in formulating explanations (M1 in the *Conclusions/Explanations row*). The following are examples provided in Chapter 3:

- 1. Describe any overall differences you observe in the culture with the changed condition. Compare the overall types and abundance of organisms to the room temperature culture.*
- 2. How has the change in conditions affected your well-being? Focus on the amount of energy and abundance of the organisms of your kind.*
- 5. Pay close attention to what is happening to other members of your community. Note any dramatic changes in their numbers or activity. How would their fate affect your survival?*

A writing assignment template is provided for students to use to submit information to submit their classroom teacher.

The following are selected comments/recommendations from the teachers and the program evaluator:

- There is an inconsistency in the procedure. The materials state to have a: “Microscope with 100X magnification (10X objective, 10X eyepiece).” Yet procedure step #5 instructs learners to view the slide at 400X magnification power.
- There is an inconsistency in the procedure Chapter 3: The Change in Environment: A Continuing Saga. Step #1 states: “Twice a week, for three full minutes, observe your organism in its new condition” while Step #4 instructs learners to “make journal entries every other day for two weeks about how your life has changed.” Wording for these two procedure steps should be consistent.
- It’s unclear if the intent of the writing assignment is to write in paragraph form or to list numbered question responses in each area of the writing assignment outline. This needs to be made more clear to the learner and the classroom teacher. It was noted that the *Teacher Resources* section implies that the activity is looking for answers to numbered questions.
- This lab activity lends itself well to be assessed with a rubric. It is recommended that a rubric for this lab be developed and included.
- An outline for a writing assignment is provided. The intent of communication is to submit information to the teacher. Although a specific layout is included, this outline would not be considered a form of communication according to the definition and descriptions of communication presented in the National Science Education Standards with regards to the intent of communication and the characteristics of the external audience.
- The interactive dichotomous key in the prelab was viewed an excellent tool, since it models how scientists use this tool to make choices.
- It is recommended that the procedure in Part A #5 should instruct learners to sketch or and identify organisms at different magnification. This would model the use of the simulated dichotomous key that was presented in the prelab.
- It is recommended that in the procedure of Chapter 3, the materials should instruct the learners to formulate a hypothesis. A prediction is referred to in Question 4: “*How does this compare to your prediction of what would happen to you.*” However, the materials never ask the learners to provide this prediction. If the intent for Question 4 is to refer back to the Prelab questions 3,4, 5, or 6, then materials need to explicitly note this.
- It is recommended that the activity provide an “Extension” that revisits Prelab questions 3,4, 5, or 6 to have students in a class compare and contrast how different abiotic factors (temperature and light) affect pond organisms.
- The materials-directed nature of is activity is appropriate.
- Provide hypertext links in Chapter 2 to existing Web-based content. This will allow teachers to print out additional background information for their students if they do not have access to the four books listed in the *Teacher Resources* section.

Explore!

The Explore! activity is 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..

Each reviewed Explore! is described below.

Ch.7 Explore!: Aerobic Exercise and Dietary Supplements

This activity begins with presenting a story about Lance Armstrong's performance at the Tour de France. Learners then engage in an information-seeking task that prompts them to answer specific questions about Lance Armstrong, aerobic exercise, and dietary supplements by reading information provided on externally linked Websites. Learners read four scenarios involving the use of performance-enhancing supplements and are told they will be researching one of these scenarios. Learners are then presented with a specific question they will be investigating (M2 in the *Questions row*):

Should the dietary supplement you are researching be regulated by an agency such as the Food and Drug Administration (FDA)?

Group member are instructed to adopt a role and are to represent that particular point of view when participating in the activity. Data is provided in the form of hypertext links to information sources on external Websites. Questions are provided to guide learners in their analysis (M2 in the *Evidence row*):

What is a dietary supplement?

What is the source of creatine? How is it made?

What is the history of creatine use?

How is creatine supposed to increase aerobic performance?

What is the mode of action of creatine in the body?

What are creatine's side effects?

Additional questions are provided to direct the learners' attention to specific pieces of evidence to assist them in their formulations of conclusion/explanations (M1 in the *Conclusions/Explanations row*):

List pros and cons of creatine use.

Discuss the role of the FDA in the regulation of dietary supplements.

Should creatine be regulated by the FDA?

Learners are directed on this page to hypertext links with related areas and sources of knowledge: "*The following resources may be helpful.*" A list of external Weblinks with one sentence descriptions is provided (*L1 in the Alternative Explanations/ Conclusions row*).

Specific content and layout to be used for communicating and justifying conclusions/explanations is specifically stated (M2 in *Communicate row*). Page 6 states: *Each group will prepare a final report of their findings. The final report must include EACH of the following:*

1. *A typed manuscript about three to five pages long, that includes each role's point of view. This can be written as a traditional research paper, an original play, or an article for a magazine or newspaper.*
2. *A debate or oral presentation to the class by all the members of your group.*
3. *And ONE of the following: video, computer slide show, web page, poster, artistic model, or display.*

Furthermore, the *CREATINE* Webpage explicitly states:

"The following information must be included in your final report:" A list of nine items is provided.

The following are selected comments/recommendations from the teachers and the program evaluator:

- Page 4 suggests that learners will be assigned one of four topics to investigate. Only the football icon resources on page 6 were available for review. It appears that the other three areas are still under development.
- A group rubric is provided. Individual accountability is not taken into account for assessment purposes. If it is important that each student actively adopt a different role, perhaps this should be taken into account in the rubric.
- External Websites are static. It was noted that many resource Weblinks do not currently exist anymore. It is recommended that the developer's create a mechanism to check externally linked Websites on a regular basis.
- Much evidence is in the form of newsmagazine type articles and reviews from various organizations. This activity could be enhanced by included actual data from scientific studies, such as scientific journals. It was noted that four links did not contain information. Perhaps these had scientific data and have been relocated or removed from the host server.
- The "aerobic" link on page 2, question 3: *"So what is aerobic exercise anyway?"* does not go to any place relevant.
- The activity provides much structure to allow learners to find background information. This is appropriate for this type of activity since it does not waste instructional time with learners using search engines to locate pertinent information.
- In each part, learners acquire background content knowledge that provides a foundation for learning new content in additional parts of the activity.

Ch. 8 Explore! Effects of Increasing Carbon Dioxide Levels

Note: The version originally reviewed with the instrument in Summer 2001 was titled *Explore! Effects of Increasing Carbon Dioxide Levels*. The activity is currently called: *Biology News Activity: Photosynthesis*.

It was determined that this activity did not meet a criterion to be classified as a partial inquiry. The activity failed to have learners formulate conclusions/explanations from evidence to address a scientifically oriented question.

The activity presents the learner with a question: *Can you design a controlled experiment to show that the rising CO₂ levels increase plant growth?* The activity provides a hypertext link to a Fastplants lab and suggests that the learner can try this experiment or create another one. The activity then states: *Create a good experimental design, show your teacher, and then do it!* No additional text is provided in the activity that addresses formulating conclusions or explanations from the experiment.

The following are selected comments/recommendations from the teachers and the program evaluator:

- This activity has the potential to be a Web-based inquiry if the learner were to do the home experiment, or if the experiment were to be conducted in a classroom. Conclusions or explanations from the experiment would have to be articulated. Scaffolding could then be used to guide learners to examine the hyper-linked articles to evaluate their findings in light of alternative explanations, provided that these articles do contain alternative explanations that reflect scientific understanding.
- Page 2 states “*Directions: After you have read the article, read the text below and answer the questions in the boxes provided.*” There are three articles presented on page 2 that offers learners an option of reading these if they desire to learn more about the phenomenon. Page 2 should explicitly state and link to the article that needs to be read in order to complete the activity.

Discussion

The prototype materials contain a variety of inquiry based Web exercises. The materials align well to the anticipated product that was stated in the *Investigating Life* NSF proposal. The Webquests, laboratories and Explore! activity can be described as materials that would actively involve students that contain essential features of inquiry.

The findings in this report strongly support that the 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 the basis of the learning experiences..
3. The modes of instruction are developmentally appropriate.

The WBI activities reviewed 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 a variety of learning styles. Materials-directed activities are provided that are very 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 familiar with experimental design.

It is recommended that rubrics and other forms of authentic assessments for selected labs and WBI activities be developed. The original NSF proposal stated that “authentic assessment opportunities such as Web-based poster presentations” would be included. A Web poster is mentioned in the guided inquiry lab and a group rubric was noted in the Explore! activity.

As additional inquiry-based activities are developed, be sure to include opportunities for learners to evaluate their explanations/conclusions in light of alternative explanations/conclusions. Take advantage of creating hypertext links to authentic scientific data on the Web for learners to evaluate during their inquiries.

Provide learners with opportunities to communicate and justify their proposed explanations and conclusions. The intent of communication is to share explanations and

conclusions in order to permit one's fellow scientists to "ask questions, examine evidence, identify faulty reasoning, point out statements that go beyond the evidence, and suggest alternative explanations for the same observations" (NRC, 2000, p. 27). This is mirrored in the content standards:

Grades 9-12. Students in school science programs should develop the abilities associated with accurate and effective communication. These include writing and following procedures, expressing concepts, reviewing information, summarizing data, using language appropriately, developing diagrams and charts, explaining statistical analysis, speaking clearly and logically, constructing a reasoned argument, and responding appropriately to critical comments (NRC, 1996, p.176)

It is recommended that *Exploring Life's* WBI activities should have learners justify conclusions and/or explanations and share that information with an "audience," not simply submit that information to the teacher. Simply completing a worksheet or stating one's conclusion in a blank or field does not qualify as communication unless there is sharing with an audience other than the teacher. An audience might consist of fellow students, other users of the Website, the Website's developer(s), or a scientist.

WEB-BASED INQUIRY FOR LEARNING SCIENCE (WBI)
INSTRUMENT MANUAL
<Beta version – 06/18/01>

Introduction

Recent science education reform initiatives (American Association for the Advancement of Science, 1993; NRC, 1996) emphasize using inquiry-based teaching to help students learn science. According to the *National Science Education Standards*, inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on evidence. Trowbridge, Bybee, and Powell (2000) contended, however, that drawing conclusions may be as valid a form of scientific inquiry as formulating explanations. They suggested that scientific inquiry should consist of asking questions, formulating hypotheses, designing experiments, gathering and analyzing data, and drawing conclusions.

The World Wide Web offers activities that provide opportunities to learn science through inquiry-based activities. Just like classroom-based science inquiry activities, Web-based inquiry activities (WBIs) for learning science may be learner-directed or materials-directed. This manual provides guidelines for how to use an instrument designed to identify and classify science WBIs on the World Wide Web.

Procedures

General Description of the Instrument

1. There are two lines for Website names and URLs, each line containing two blanks.
2. The left-hand blank on the first line is for the complete name of the Website.
3. The right-hand blank on the first line is where you write the URL of the home page of the Website.
4. The left-hand blank on the second line is for the complete name of the activity you are analyzing.
5. The right-hand blank on the second line is where you record the root URL for the activity you are analyzing.
6. Review the instrument. You will observe that it is a matrix made up of 5 rows and 4 columns. The 5 rows describe the five possible essential features of inquiry. The 4 columns describe the degree to which the WBI is either learner-directed (left two columns) or materials-directed (right two columns). Notice that there are 6 sub-columns in the fourth row. These represent subdivisions of the four columns, with

only one division each for the extreme left and right columns and two subdivisions in each of the center two columns.

7. Notice that there is a column descriptor at the bottom of each of the four columns. These statements summarize the guiding philosophy for all cells in that column. Note also that each cell in the matrix contains a sentence or two that describes what WBIs falling into that cell would exhibit as properties.

General Procedure for Completing the Instrument

1. You should work methodically row by row, classifying the WBI into the cell that best matches how it addresses that essential feature of inquiry. Recognize that not all WBIs will fall into a cell in each row, although each must match one cell in each of the first three rows in order to qualify as a WBI.
2. As you complete each row in the instrument, select the **cell** in that row that matches that Essential Feature of Inquiry criteria. In the space in that cell, **write the exact words from the Website** that most closely match the descriptive sentence or sentences for the properties of that cell. If you cannot provide exact words, write a brief description describing why you feel the WBI fall into that particular cell of the row.
3. **Write the Web address location for this text in the selected variation cell.** The Web address should include all location information displayed after the Root URL. Use a "/" to identify the Root URL.

For example: You are evaluating *the Shell Island Dilemma* (<http://www.ncsu.edu/coast/shell/index.html>). You locate a list of evidence that learners are asked to analyze on the following Webpage: <http://www.ncsu.edu/coast/shell/resources.html>. You would write: ***/resources.html*** in the appropriate variation cell of the *evidence row* to identify this Website location.

Specific Guidelines for Completing the Instrument

Six sections follow. The first provides criteria for determining if an activity qualifies as a WBI. The next six sections provide rules for determining into which cell in a particular row a WBI should be classified.

Qualification Criteria

In order for an activity on a Website to qualify as a WBI, it must meet all 6 of the criteria in this section.

Criterion #1: A WBI must contain at least the first three essential features of classroom inquiry described in *Inquiry and the National Science Education Standards* (Olson & Loucks-Horsley, 2000), as modified to address the possibility of conclusions rather than explanations (Trowbridge, Bybee, and Powell, 2000):

1. Learners are engaged by scientifically oriented questions.
Scientifically oriented questions may be stated explicitly or may be implied as a task.
2. Learners give priority to evidence, which allows them to draw conclusions and/or develop and evaluate explanations that address scientifically oriented questions.
3. Learners draw conclusions and/or formulate explanations from evidence to address scientifically oriented questions.

Criterion #2: The WBI must be learner-directed.

The WBI should be phrased in such a way that learners would perceive it as directed at them. That is, the majority of the wording used in the WBI should be directed at the learner (“you”), not at the teacher (“your students”). The following example from the *Albatross Project - Hawaii Study* (<http://www.wfu.edu/albatross/hawaii/ideas.htm>) is specifically directed at the student:

How will you use satellite tracking data?

First decide what hypotheses you want to test, like what questions you want to answer. Here are some ideas:

- *Hypothesis 1 -- Laysan and black-footed albatrosses fly at the same speed*
- *Hypothesis 2 -- male and female albatrosses fly to the same places to find food*
- *Hypothesis 3 -- albatrosses don't care at all about the surface temperature of the ocean*

Are these hypotheses correct? If they are, keep 'em. If they're not, chuck 'em. You can think up lots of other hypotheses to test to advance albatross science! Do it! Also, check out the details below. You'll need to know them.

Some minor wording confusion in a WBI is acceptable, however, provided the majority of the phrasing is still directed at the learner. For instance, some WBIs may be directed at both the learner and a classroom teacher on the same Web page. The following example from *the Shell Island Dilemma*: <http://www.ncsu.edu/coast/shell/index.html> is directed at both (text directed at teacher in **bold**; ambiguously directed text underlined):

Divide your class into different stakeholder roles.

As you explore the resources, remember that you are in the role of a stakeholder. Think about and try to determine the current North Carolina policies regarding

the placement of hard structures in public trust areas such as the beach. How does the current coastal policy affect your vested interests as a stakeholder?

Click on your stakeholder name above to read a brief description of your stakeholder role and to see a recommended list of important resources to review.

After reviewing the resources, prepare a statement to decide what should be the next course of action regarding the Shell Island Resort. You will present your statement in a debate to decide the future of the Shell Island Resort. Each student should complete a Position Statement Handout.

After students have had enough time to review the resources and prepare their position statements, hold a debate to decide the next course of action.

When the debate is complete, take a vote on the proposed solutions and conclude the debate when a consensus of 2/3 of the class agrees on a proposed solution.

Activities directed solely at classroom teachers, such as teacher-centered organized lesson plans, do **not** meet the criteria of Rule #2. For example, *Square of Life* (<http://k12science.org/curriculum/squareproj>) is specifically directed at a classroom teacher:

Procedures

Activity #1: Project Introduction

For this activity, do the following:

- 1. Introduce this lesson by reading aloud one or more of the books listed below (or choose a similar book). The goal is to engage the students' interest and curiosity and to get them excited about working with students from all over the world.*
- 2. For older students you can stop occasionally and point out where some of the places they are reading about are located on a world map.*
- 3. After reading and discussing the book(s) explain that they are going to start a project to learn what it is like to live in other parts of the world. Tell them that they are going to use the computer and the Internet to communicate or "talk" with other students from all around the world. Relate this to the books if possible.*

Criterion #3: The WBI must support student learning of a science concept or science content.

Science WBIs must fall into a recognized science discipline (biology, chemistry, physics, environmental sciences, astronomy, oceanography, and the like). For example, science concepts might address the relationships among chemical nutrients in a stream or the distribution of genetic traits in a population. Similarly, science content might include the study of how light travels or how materials exist in different states of matter.

Criterion #4: The WBI must be Web-based. That is, a WBI is more than printed material placed on the Web, describing how an inquiry activity may be completed. Instead, a WBI should go beyond simply being reformatted text from a printed sheet. It should be enhanced or customized to take advantage of the features of the Web to deliver instruction.

WBIs may use hypertext links to additional materials, email, video, graphics, animation, audio, virtual reality, simulation, or other forms of interactivity. *Space Food and Nutrition* (available online at

<http://spacelink.nasa.gov/products/Space.Food.and.Nutrition/>) is an example of a Web-delivered print material that would not be considered a WBI. This Website offers activities from printed materials that are in no way enhanced for delivery on the Web, other than including hypertext links for navigation within the document. In fact, the very same materials are available from the site as a downloadable 1.9 MB PDF file. Another Website, *EnergyNet* (available online at <http://www.energynet.net>) consists of a downloadable PowerPoint presentation for use in class by the teacher. *Space Food and Nutrition* and *EnergyNet*, therefore, do not qualify as WBIs.

Criterion #5: Evidence used in a WBI should be of the same type an actual scientist would use.

For example, WBIs might contain links to rich databases of real-time scientific data, such as meteorological data that learners can use to examine trends in weather patterns. Web-based data might also be empirical data collection by a learner and then shared with others in an online database. Such data may be either learner-collected using a hands-on laboratory protocol supplied (or suggested) by the Website, or may be provided to the learner in the form of self-contained data sets. Learners may also collect data for analysis remotely in real time or near-real time.

Criterion #6: Conclusions and/or explanations must involve reasoning.

Conclusions and/or explanations in WBIs should be more than simple data analysis and reporting. Conclusions/explanations may include task-oriented activities, such as locating the optimal placement of an observatory, figuring out the life expectancy of an animal using a simulation, or explaining observations (for instance, the appearance of bread mold).

While the intent of hints and immediate feedback in an activity is to support learner inquiries, if learners choose such support prior to completing the inquiry or before giving thought to what they have found, the inquiry process may be "short-circuited." That is, the activity may cease to be inquiry. *Fun With Fomites* (<http://www.microbe.org/experiment/fomites.asp>) is an example of such a "short-circuited" inquiry. If learners access the immediate feedback links on this Website, not only are they told how to interpret the data, but they are also provided with reasoning to draw a conclusion/formulate an explanation. An activity in which the learner no longer has any major responsibilities for data analysis or reasoning is no longer inquiry.

When you encounter a site where learners control seeing such hints and feedback, you should note on the instrument if you believe that seeing them would end the inquiry. You can then classify the activity as a WBI, provided learners do not use the hints or feedback. Of course, if learners cannot control the presentation of hints or feedback and the content of such hints and feedback eliminates the required learner reasoning, you must disqualify the activity as a WBI (and note on the instrument why you have done so – usually by quoting relevant hints, feedback, or conclusions/explanations and noting that their appearance could not be controlled by the learner).

General Classification Rules

The following are general rules designed to help you make decisions about which cell in a row best matches what a WBI offers.

Rule #1: When in doubt, use the **philosophy column description** located at the bottom of each column to make decisions. These descriptions guide your cell selections.

Rule #2: When several activities are presented in a clear sequence leading to a final activity that is dependent upon completing those earlier activities, treat the full set of activities as one WBI.

For example, *Navigational Vectors* (<http://k12science.org/curriculum/vectors/>) requires learners to work through a sequence of learning tasks that culminate in a final activity addressing the scientifically oriented question.

Rule #3: When a WBI consists of multiple activities and these activities fall into different cells, note each activity's URL in the appropriate cell when completing the instrument.

For example, **collaborative experiments** in WBIs illustrate two ways to classify evidence, each calling for categorization in a different cell. First, the learner is provided with a protocol and collects certain data (L1). These data are then contributed to a collective database. Next, the WBI provides learners with cumulative data from remote geographical placements and instructs the learner in how to analyze the cumulative data (M1). Thus, in collaborative experiments, there is first a learner-centered component (L1), followed by a materials-centered component (M1). Examples of collaborative experiments include *Boil, Boil, Toil, and Trouble* (<http://k12science.org/curriculum/boilproj/index.html>) and *KanCRN - Keeping an Eye on Ozone* (<http://kancrn.org/ozone/>).

Question Rules

The following rules are designed to assist you in selecting appropriate cells for WBI activities in the first row.

Rule #4: Scientifically oriented questions may be stated explicitly or may be implied as a task.

For example, *Athena - Predicting the Weather* (<http://www.athena.ivv.nasa.gov/curric/weather/hsweathr/index.html>) uses an implicit task:

“Your task now is to make a forecast for the next several days and compare it with the real weather that occurs.”

This statement can be converted into a question to engage the learner. The implicit question in this WBI becomes, “How does your forecast for the next few days' weather compare to the actual weather?”

Rule #5: When a WBI prompts learners to formulate their own questions or hypotheses to be tested, it should be placed in the L2 *question* row cell.

An example from the *Albatross Project* (<http://www.wfu.edu/albatross/hawaii/ideas.htm>) illustrates this:

*“Are these hypotheses correct? If they are, keep 'em. If they're not, chuck 'em.
You can think up lots of other hypotheses to test to advance albatross science! Do it! Also, check out the details below. You'll need to know them.”*

Rule #6: A WBI that suggests topic areas or provides samples to help learners formulate their own question or hypothesis should be placed in the L1 cell of the *question* row.

WOW: Investigating Data Interpretation (<http://wow.nrri.umn.edu/wow/student/data/inquiry.html>) suggests possible topics:

“In this lesson you will formulate and answer your own research question. Your question can be a water quality issue you have always wondered about, a class topic you wish to explore in greater detail, or an issue that has been in the news recently.”

Rule #7: A WBI that offers the learner lists of questions or hypotheses from which to select should be placed in the M1 cell of the *question* row.

For example, *Boil, Boil, Toil, and Trouble* (<http://k12science.stevens-tech.edu/curriculum/boilproj/questions.html>) offers such a list:

"The questions below are suggestions for help in determining a hypothesis for the project, follow-up discussions or further exploration. Students could address some of these questions or try to make comparisons of their own. Students could address some of these questions in their final reports.

1. *Which factor in the experiment showed the strongest correlation to boiling point? What "proof" do you have to back up your answer?*
2. *What was your original hypothesis? Were you surprised at your results? Were you surprised at other classes' results?*
3. *What explanation can you give for your results?*
4. *Pick a different location from where you are. Predict what the boiling point of water would be at that location. Would it be higher or lower than what you found at your location? Why?*
5. *How important is accuracy of measurements in this experiment? Were there any possibilities for inaccurate measurements in your experiment? What might they be?*
6. *What would you change if you could repeat the experiment?*
7. *Is there another variable you would like to test to see how it might affect boiling point?"*

Rule #8: When a WBI provides the learner with specific stated (or implied) question/hypothesis to investigate, that WBI should be placed in the M1 cell of the *question* row.

For instance, *Find Out Why - What Wrap Does the Best Job at Protecting Holiday Treats?* (<http://www.nsf.gov/od/lpa/events/fow/fowtfkv2n2/htm/wrapfun.htm>) provides two such questions:

What is the best wrap to use for each treat?
Can you use the same type of wrap for every treat?

Evidence Rules

The following rules are designed to help you decide which cell in the second row best matches what a WBI offers.

Rule #9: If the learner collects data outside the Website, then the WBI is placed on the **L** side of the instrument. If the WBI provides the learner with data, the WBI is placed on the **M** side of the instrument. M1 and M2 WBIs are further distinguished by the amount of direction the WBI provides about how data should be analyzed.

Rule #10: When the learner determines what constitutes evidence and develops procedures and protocols for gathering relevant data (as appropriate), that WBI is classified as L2 in the *evidence* row.

The *Remote Access Online Real-Time Science Experiment-- Biological Clocks in Nature – Student Activity* (http://www.cbt.virginia.edu/Olh/middle/activ_m/nature.html) suggests a possible data-collection protocol:

"Design a method for recording what you are observing. Remember you can use any of your senses. For example, you may want to tape record the noises you hear."

Rule #11: When a WBI directs learners to collect certain data, or only provides a portion of the needed data, it should be classified as L1 in the *evidence* row.

Often the WBI provides protocols for data collection. For example, *Bagheera (CS2-8)* (http://www.bagheera.com/inthewild/class_activities.htm) provided only a portion of the needed data; in this case, only the database field names:

*"Design a database of the extinct species in this curriculum that includes the following categories of information: **species**; **scientific name**; **classification** (e.g., mammal, reptile, bird, amphibian); **location** (e.g., Brazilian rain forests); **habitat** (e.g., forest, ocean, grassland); **population decline over time causes of endangerment** (or causes of extinction, if extinct)."*

In a different L1 example in the *evidence* row, the *CERES Project- Mountainquest* WBI (<http://btc.montana.edu/ceres/html/mountainquest.htm>) directs learners to an external Website to collect data.

Rule #12: WBIs that provide data and ask learners to analyze them are classified as M1 in the *evidence* row.

For example, *Carolina Coastal Science - Relocating a Lighthouse* (<http://www.ncsu.edu/coast/chl/index.html>) states:

*Here are the Web-based resources to use to identify and investigate the issues:
[A list of hypertext links to resources on the Website are provided]*

Rule #13: WBIs that provides data and give specific direction on how data are to be analyzed should be classified as M2.

For example, the *Genetics Science Learning Center - The Farmer's Bones* (<http://gslc.genetics.utah.edu/society/farmer/index.html>) provides specific directions:

1. Click on each graphic for a larger representation.
 2. Identify the bone as well as any distinguishing characteristics. Write these down in the space provided. ****Remember... a good scientist writes everything down.**
-

Conclusions/Explanations Rules

The following rules are designed to assist you in selecting appropriate cells for WBI activities in the third row.

Rule #14: The amount of direction a WBI provides the learner is the main determinant of whether an activity is placed on the **L** or **M** side of the instrument in the *conclusions/explanations* row.

Rule #15: What distinguishes M1 and M2 WBIs from one another is whether they are verification-type activities or not. If the WBI directs learner attention (often through questions) to specific pieces of evidence to lead learners to predetermined correct conclusion/explanation, it is classified as M2. If the WBI directs learner attention (often through questions) to specific pieces of evidence to draw their own conclusions or formulate explanations, the WBI is classified as M1.

Boil, Boil, Toil and Trouble (<http://k12science.stevens-tech.edu/curriculum/boilproj/example.html>) is an example of an M2 WBI for the *conclusions/explanations* row, since the relationship of the boiling point of water at different elevations is already documented.

Carolina Coastal Science - Shell Island Dilemma (<http://www.ncsu.edu/coast/shell/index.html>) is an example of an M2 WBI for the *conclusions/explanations* row, since the learner is investigating an authentic problem that has no known solution.

Rule #16: A WBI is classified as L1 in the *conclusions/explanations* row if it prompts learner to think about how evidence leads to conclusions/explanations, but does not cite specific evidence.

Water on the Web -- Investigating Data Interpretation (<http://wow.nrri.umn.edu/wow/student/data/inquiry.html>) is a good example:

Sometimes, data are found that defy the observed pattern. These are known as data outliers. Rather than dismiss them as unimportant, try to determine their cause. (e.g.: Is the probe working properly?) Sometimes outliers lead to new and interesting interpretations of the data. Were there

any outliers in the data you collected? Be prepared to explain how you chose to handle outliers in your data analysis.

Rule #17: A WBI is classified as L2 in the *conclusions/explanations* row if the WBI prompts learner to analyze data and formulate own conclusions/explanations.

The following examples illustrate this:

"Can you think of anything that may explain your results?"
(From *CIESE Online Classroom Projects - Down the Drain*
<http://k12science.org/curriculum/drainproj/>)

"Compare your graphs. Can you draw some conclusions?"
(From *Bagheera* (G2-1 & G2-2)
http://www.bagheera.com/inthewild/class_activities.htm)

"Consider possible explanations for your experimental results."
(From *Water on the Web - Investigating Aquatic Respiration* -
<http://wow.nrri.umn.edu/wow/student/aquatic/inquiry.html>)

Alternative Conclusions/Explanations Rules

The following rules are designed to help you decide which cell in the fourth row best matches what a WBI offers.

Rule #18: The presence or absence of hypertext links to alternative conclusions/explanations separates the **L** side of the instrument from the **M** side of the instrument.

Rule #19: A WBI that explicitly states specific connections, but does not provide hypertext links is classified as M2 in the *alternative conclusions/ explanations* row.

For example, *KanCRN - How Does Your Cookie Crumble?*
(<http://kancrn.kckps.k12.ks.us/cookie/index.cfm>) presents questions that identify other possible connections:

Do most males like the same brand of cookie? Do most ten year olds like the same brand of cookie? Did most ten year old males choose the same "most important characteristic"?

Rule #20: WBIs that suggest or imply possible connections to alternative conclusions/explanations should be classified in the right-hand M1 cell.

For example, *Water on the Web - Investigating Data Interpretation* (<http://wow.nrri.umn.edu/wow/student/data/inquiry.html>) provides the following questions to assist learners in thinking about their results:

*Was data collected by RUSS possibly affected by external factors?
Did you find any outliers? How can the outliers be explained?*

Rule #21: WBIs that identify areas and sources of scientific knowledge that could be useful, but do not provide hypertext links are placed in the left-hand M1 cell of the *alternative conclusions/explanations* row.

Rule #22: WBIs that provide a “catalyst” to prompt learners to examine other resources and form connections to conclusions/explanations independently (without guidance) are classified as L2 in the *alternative conclusions/explanations* row. Catalysts are designed to encourage the learner to think about the possibilities, but L2 alternative conclusions/explanations WBIs not provide learners with hypertext links to sources of information about alternative conclusions/explanations.

Examples of catalysts include:

Can you come up with possible explanations for the few stray values that occur along the growth curve?

(From *Chickscope*

http://chickscope.beckman.uiuc.edu/explore/biological_imaging/)

Consider possible explanations for your experimental results.

(From *Water on the Web - Investigating Aquatic Respiration -*

<http://wow.nrri.umn.edu/wow/student/aquatic/inquiry.html>)

Rule #23: A WBI that provides hypertext links to alternative conclusions/explanations but does not refer to them should be placed in the left-hand L1 column of the *alternative conclusions/explanations* row. The learner must independently examine other resources and form connections to other conclusions/explanations.

For example, the *CERES Project- Mountainquest*

(<http://btc.montana.edu/ceres/html/mountainquest.htm>) is classified in the left-side L1 column. In this WBI, the learner must independently examine other resources containing alternative conclusions/explanations that are embedded in team assignments. These hypertext links are not explicitly cited and the learner must independently decide to use this information.

Rule #24: A WBI that directs learners to hypertext links related to areas and sources of scientific knowledge should be placed in the right-hand L1 column of the *alternative conclusions/explanations* row.

For example, *Carolina Coastal Science - Shell Island Dilemma* (<http://www.ncsu.edu/coast/shell/index.html>) provides, among its hyperlink resources, alternative explanations from coastal geologists about the effects of building a hard structure at a migrating inlet.

Communication Rules

The following rules are designed to help you select appropriate cells for WBI activities in the fifth row.

Rule #25: Communication is determined by what the WBI solicits, not what learners submit to the Website.

The *Kancrn - Keeping an Eye on Ozone* (<http://kancrn.org/ozone/>) WBI specifies a specific format for learners to use when they communicate their conclusions, a format including certain sections. When one examines the actual reports, however, the specified *Data Analysis*, *Conclusions*, and *Future Research* sections of submitted student reports are not completed. By design, the WBI includes the final essential feature of inquiry. While learner response may affect the quality of learner experience, it does not change the intended communication function of the WBI.

Rule #26: Simply sharing data on a Web-based form does not constitute communication. Communication is of the conclusion/explanation, not the data.

For example, *Mission to Eros: Rendezvous with an Asteroid* (<http://k12science.stevens-tech.edu/nasa2/>) does not qualify as the type of communication intended for the fifth essential feature of a WBI, since all learners did was post data to a database.

Rule #27: Using right-sounding words is not enough; the WBI must actually solicit communication.

Don't be fooled by wording. Some Websites imply that they are providing learners with authentic communication opportunities, but do not deliver on that promise. For example, *The Remote Access Online Real-time Science Experiment Website* (<http://www.cbt.virginia.edu/Olh/exp.html>) states on the opening page that learners will "share conclusions with other scientists from all over the world." However, this does not appear to be the case. Although the Website implies communication by using terms such as *communicate*, *e-mail*, and *talk to* throughout the Website, students do not communicate conclusions or explanations on the Website and e-mail appears to be used solely to ask scientists questions about the data themselves.

Rule #28: If instructions in the WBI about communication do not address content and/or layout, the WBI is classified as L1 or L2 in the *communicate* row. If those instructions focus on content and/or layout, the WBI is classified as M1 or M2.

Rule #29: WBIs that are very open-ended in terms of learners making decisions about techniques to use in presenting their results fall into the L2 cell of the *communicate* row. These WBIs remind the learner of the general purpose of communication and the need for communication, but do not provide specific guidance.

For example, the *Chickscope* activity (http://chickscope.beckman.uiuc.edu/explore/biological_imaging/) prompts the learner: *Share your results, conclusions, and questions with other classrooms on the Web.*

Rule #30: When WBIs talk about how to improve communication, but do not suggest specific content or layout approaches to be used, they are classified as L1 in the *communicate* row.

For example, a WBI classified as L1 in the *communicate* row might well suggest that the learner be sensitive to some aspects of his intended audience, such as reading or grade level, science expertise, or prior experience with the topic.

Rule #31: Distinguishing between M1 and M2 WBIs in the *communicate* row is based on how directive they are about the learner's presentation. WBIs with clear specifications for the content and/or layout to be used to communicate the conclusion/explanation fall into the M2 cell, while WBIs that suggest possible content and/or layout for the presentation fall into the M1 cell.

The *Athena - Predicting the Weather* activity (<http://www.athena.ivv.nasa.gov/curric/weather/hsweathr/index.html>) is classified as M2:

As a weather forecaster you must explain these maps to your viewing or reading audience. Write a weather report explaining your forecast sequence. Include forecasts for Chicago, Memphis, and Denver. Discuss changes in pressure, wind direction, wind speed, temperature, and sky condition.

The CERES Project - Moonquest (<http://btc.montana.edu/ceres/html/Quemoon1.html>) is classified as M1:

Your job is to report the findings of the Historians and the Fact Finders to the class. You will work with the Graphic Design team to create a presentation that's out of this world. How you make the presentation is limited only by your imagination: You can use graphs, charts, overheads, computer graphics, etc.

Website Name: _____ Website URL: _____

Specific Activity Name: _____ Specific Activity (Root) URL: _____

	Learner Directed		Materials Directed	
	L2	L1	M1	M2
Essential Feature of Inquiry Learners are engaged by scientifically oriented questions.	Prompts learner to formulate own question or hypothesis to be tested.	Suggests topic areas or provides samples to help learner formulate own question or hypothesis.	Offers learner lists of questions or hypotheses from which to select.	Provides learner with specific question/hypothesis to be investigated.
Learners give priority to evidence, which allows them to draw conclusions and/or develop and evaluate explanations that address scientifically oriented questions.	Learner determines what constitutes evidence and develops procedures and protocols for gathering relevant data (as appropriate).	Directs learner to collect certain data, or only provides portion of needed data. Often provides protocols for data collection.	Provides data and asks learner to analyze.	Provides data and gives specific direction on how data to be analyzed.
Learners formulate conclusions / explanations from evidence to address scientifically oriented questions.	Prompts learner to analyze evidence (often in the form of data) and formulate own conclusions/explanations.	Prompts learner to think about how evidence leads to conclusions/explanations, but does not cite specific evidence.	Directs learner attention (often through questions) to specific pieces of evidence (often in the form of data) to draw conclusions and/or formulate explanations.	Directs learner attention (often through questions) to specific pieces of evidence (often in the form of data) to lead learner to predetermined correct conclusion/explanation (verification).
Learners evaluate their conclusions / explanations in light of alternative conclusions/ explanations, particularly those reflecting scientific understanding.	Prompts learner to examine other resources and make connections to conclusions and/or explanations independently (“Catalyst”).	Provides hypertext links but does not refer to them. Learner examines other resources and make connections to conclusions and/or explanations.	Identifies areas and sources of scientific knowledge that could be useful, but does not provide hypertext links.	Explicitly states specific connections, but does not provide hypertext links.
Learners communicate and justify their proposed conclusions / explanations.	Reminds learner of general purpose of communication and/or need for communication, but gives no specific guidance.	Talks about how to improve communication, but does not suggest content or layout.	Suggests possible content to include and/or layout that might be used.	Specifies content to be included and/or layout to be used.

Learner-driven with much initiative and independence. Learner makes decisions, but with support and scaffolding, particularly with the process. Learner does much selecting from provided materials. Limited choices. Materials-driven. Learner makes few choices and is given much direction.