Instruction for Problem-Based Learning

Shelagh A. Gallagher, Ph.D.
Engaged Education
Charlotte, NC

gallagher5@carolina.rr.com
a changing world
The new age of science is marked by the dissolution of barriers across traditional disciplines and fields. Scientists are grouping and regrouping not based on similarity in background, but to ensure that diverse perspectives are considered.

Lewis Thomas
Unraveling Complexity

Over the course of a year of office practice—which, by definition, excludes the patients seen in the hospital—physicians each evaluated an average of 250 different primary diseases and conditions. Their patients had more than 900 other active medical problems that had to be taken into account.

Atul Gawande
Books are published at such a rapid rate that they make us exponentially more ignorant. If a person read a book a day, he would be neglecting four thousand others, published the same day. In other words, the books he didn’t read would pile up four thousand times faster than the books he did read, and his ignorance would grow four thousand times faster than his knowledge.

Gabriel Zaid, So Many Books
passionate, engaged
life long learners
from

novice STUDENTS
creative EXPERTS
Stage 1: Romance
The most exciting phrase to hear in science, the one that heralds the most discoveries is not ‘Eureka!’ (I found it!) but ‘That’s funny...’.
Curiosity is not enough. The word is too mild by far,… Passion is indispensable for creation, no less in the sciences than in the arts…This is the rage to know. *Judson, The Search for Solutions.*
All of these people; whether they're doing artistic work or scientific work, are trying to solve a problem .... And the problems at first seem difficult, and perhaps insoluble. And you work very hard trying to understand, trying to fill yourself full of the problem, just to know what barriers you're trying to crack.

Murray Gell Manns
Stage 2: Precision
There is a tremendous amount of work that you have to do to get your idea to come to life. But you’re not going to do that work if you don’t have the idea; if you don’t have that inspiration, that love.

I didn’t know that you could not improve the fibers easily through plant breeding; I thought it would be fairly straightforward and then WHAM, it’s extremely complex. But by then I was hooked.

Sally Fox, Entomologist
Stage 3: Generalization
Creating a new theory is not like destroying an old barn and erecting a skyscraper in its place. It is rather like climbing a mountain, gaining new and wider views, discovering unexpected connections between our starting points and its rich environment. But the point from which we started out still exists and …forms a tiny part of our broad view gained by the mastery of the obstacles on our adventurous way up. *Albert Einstein.*
Once a scientist experiences the exhilaration of discovery — then he is hooked and no other life will do.

P.D. Medewar
To Make Learning Look like the Real World

- Use problems at the beginning, not the end
- Use ill-structured problems
- Relate all learning to the problem
- Make students apprentices
- Give students responsibility for problem definition and plan of action
- Have student defend their resolution using criteria which are meaningful to the discipline.
a different approach
Welcome to The Prairie!
<table>
<thead>
<tr>
<th>What do we know?</th>
<th>What are our Learning Issues?</th>
<th>What is our Action Plan?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Text</td>
<td>Text</td>
<td>Text</td>
</tr>
</tbody>
</table>
Time to Reflect

Tuesday, July 2, 13
What is “Problem-Based Learning”?  

A form of inquiry-based education, originally invented for medical school, where learning is initiated with an ill-structured problem and students learn to direct their own course of study.
Oversimplification and dogmatism are the twin enemies of creative thought.

Premature closure on a productive question can destroy imagination.

Concepts are worthless unless they lead children to new explorations.

Answers have a way of killing thought.
An Immersion in Apprenticeship through an Expert’s Point of View
What is An Apprenticeship?

The purpose of an apprenticeship is to provide both hands-on training and theoretical instruction so that an interested person can learn the full range of skills and information behind a highly skilled occupation. By participating in an apprenticeship, he can learn the subtleties of the craft from an expert and can begin his own practice under close observation.
Instructional Goals of PBL

Core Content
Problem Solving
Conceptual Reasoning
Research
Dispositions
Thinking Skills
Ethics
Key Components of PBL

- Initiating Instruction with an Ill-Structured Problem
- Student-as-Stakeholder
- Teacher as (Metacognitive) Coach
Ill-Structured Problems are the Center of *PBL Curriculum* because they are the Center of *Expert Activity*
Ill-Structured Problems

• “...cannot be defined with a high degree of completeness... cannot be solved with a high degree of certainty

• (King & Kitchener, 1994)
The Ill-Structured Problem

- Needs more information before it becomes clear
- Can be solved in more than one way
- Has more than one resolution
- Changes sometimes with new information
- Is ambiguous and unclear
Educational Value of Ill-Structured

• Reveal why information is necessary
• Allows for interconnections within and between disciplines
• Provides the full scope of a field (habits of mind, values, and tacit knowledge)
• Allows student questions to drive learning, controlled by careful problem design
• Triggers deep-level, sophisticated reasoning
• Support authentic use of conceptual reasoning
PBL Curriculum

is *Storytelling*

Narrative is *Memorable*
Real world problem solvers are not objective: we have perspective (bias)

- Increases ownership
- Provides a form of apprenticeship in a discipline
- Authority, Responsibility, Accountability
Metacognitive Coach
The PBL Coach

- Cruise Director

- Socrates
Laying out the Plan...

The Flow of the Problem
## Goals for *Ferret it Out*

<table>
<thead>
<tr>
<th>PBL Goal</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content</td>
<td>Habitats, Food Web, Biomes, Genetic Drift, Human Impact</td>
</tr>
<tr>
<td>Concept</td>
<td>Systems</td>
</tr>
<tr>
<td>Research</td>
<td>Primary Resources, Modeling</td>
</tr>
<tr>
<td>Dispositions</td>
<td>Perspective</td>
</tr>
<tr>
<td>Thinking Skills</td>
<td>Cause-Effect, Risk Assessment, Problem Solving</td>
</tr>
<tr>
<td>Ethics</td>
<td>Competing Needs</td>
</tr>
</tbody>
</table>
The Flow of the Problem

Engagement

Inquiry and Investigation

Problem Definition

Problem Resolution

Problem Debriefing

Tuesday, July 2, 13
Problem Engagement
1. The BFFRIT

Inquiry and Investigation
1. Ferret Facts (research)
2. Habitat Threats
3. Systems and Risk
4. What’s the Source
5. Problem Definition

Resolution
1. The Model
2. Presentation

Debriefing
1. Review/Reflect/Extend
Embedded Instruction

- Research Skills
  - Internet Search
  - Primary Resources
- Analysis
  - Comparing/Contrasting Points of View
  - Cause and Effect
- Creating Criteria
- Comparing Options
Investigation
Fire Ravages McClintock Farm

BY TAMARA ROHINS

Searing temperatures and drought conditions created a recipe for disasters yesterday afternoon for one of Fort Collins’ oldest established ranches. Ranch hands at McClintock Farm report that just before noon they noticed thick, black smoke trailing up from the western edge of the property.

The Fire Authority, along with Union Colony Fire and Rescue were dispatched and arrived on the scene within a matter of minutes. Firefighters worked tirelessly to control the conflagration, but weather conditions were not on their side. It took over six hours to control the blaze, and when firefighters were finally able to extinguish it over 2,000 acres of land had been blackened. Captain Anthony Ramirez stated, “We tried our best we could to contain the fire quickly, but with the heat and the abundance of cheat grass we were fighting an uphill battle.”

Ranch owner, Clive Murphy, said that he was thankful for the efforts of “hard working firefighters” fighting the blaze.

Fink, Poison or Proliferate: What to do about the Prairie Dog

FOR SUCH a small creature, the prairie dog certainly believe that prairie dogs are ruining the public ever be reached?

Juror’s Award of Excellence Goes to Global Warming

What Should Be Done?

Fort Collins Coloradoan

Tuesday, April 3, 2010

The Forecast

Sunny
High 92
Low 70

Royal Fireworks Press
Internet Resources

Print

Video

Ferret webcam

Audio

Basic Information about Ferrets, Recovery and Habitat Issues

The Black-Footed Ferret Recovery Implementation Team. The website for the group that is the basis for the students’ stakeholder role. Excellent information and engaging video clips. http://www.black-footedferret.org/

US Fish and Wildlife Service Species Profile: Black-Footed Ferret. Information about the black-footed ferret from the official Endangered Species list. This site includes a map that shows where
MLA Note Taking

Learning Issue Question: __________________________________________________________

MLA CITATION STYLE:
Last name, First name. “Title of Work.” Source. City of Publication: Publisher, Year.

Type (circle one): Book Magazine Website Other ____________________

(Include PAGE NUMBERS in your notes, especially if you write down a QUOTATION from the text).

1. Citation: _________________________________________________________________

___________________________________________________________________________

Information Related to my Question: ___________________________________________

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________

___________________________________________________________________________
Biomes

Grassland Biomes of the World
Habitats

Teacher Reference

Prairie Ecosystem Template

Instructions: Complete the chart with pictures or descriptions of each element of the prairie ecosystem. Include the black-footed ferret and the prairie dog, along with at least one predator and one food source. Label elements using scientific terminology.

Climate: 12.6 inches of rain/year
Sunny, little or no shade from trees

Edaphic
Producers:
Grasses

Heterotroph
Primary
Carnivore
Black-footed ferret

Saprotroph
Decomposer
Worm, Dung Beetle

Heterotroph
Secondary
Carnivore
Coyote

Farming/Overgrazing

Inorganic Matter
Soil
Math!

Problem Log

Two Ferrets and 200 Prairie Dogs on 13.34 Acres

Problem Log

Two Ferrets and Prairie Dogs after Plague Epidemic

Key
- Ferret
- Prairie Dog

111

112
Date:
To: All Team Members
From: Mitchell Ladner, US Fish and Wildlife Service
Subject: Ft. Collins Project

By now your work is well underway on this project. I would like to know about your findings, your ideas about the direction we should take to optimize the success of our reintroduction efforts, and a description of any issues you’ve encountered thus far. Please send me a written response with your thoughts to date. I’ll expect your update by tomorrow.

Problem Log

Reflective Moment: A Letter to the Boss

Write a letter to Mitchell Ladner providing him with the requested update.

A quality response includes: 1) a header 2) a salutation, 3) a body of at least two paragraphs, each presenting a major idea that is supported by facts, and 4) a closing.
Inquiry
Critical thinking!

Problem Log

Determining Causes

Directions: Use this space to record the cause-effect relationships among the Critical Components from the Black-Footed Ferrit Habitat Chart. Use arrows to connect each fact to its prior cause. If there is a Critical Component that you think is important, but not directly connected, included in the chart but don’t connect it to other Critical Components. Feel free to add boxes as needed.
Critical Thinking!

Example: Why did some children start living away from home in order to work?

<table>
<thead>
<tr>
<th>Indirect Causes</th>
<th>Indirect Causes</th>
<th>Immediate Causes</th>
<th>Current Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ferrets killed</td>
<td>Genetic bottleneck</td>
<td>Too much inbreeding</td>
<td>Weakened condition</td>
</tr>
<tr>
<td>Inadequate food source</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prairie dogs killed</td>
<td>Not enough prairie dogs</td>
<td>Inadequate food source</td>
<td></td>
</tr>
<tr>
<td>Plague</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Changed ecosystem</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PARENT</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Ferret does not thrive when reintroduced into the wild.
Genetic Bottleneck Demonstration

The Genetic Bottleneck Data Sample #1

Directions: Complete this chart to create a model of what happens when there is a dramatic decrease in an animal population. Draw a bead from your bag without looking, mark the color, and then replace the bead before drawing again. Do this 20 times each for Generation 5, Generation 6, and Generation 7. For Generation 8, when the population begins to recover, draw 40 beads, using the same method as described above.

<table>
<thead>
<tr>
<th>Trait/Color</th>
<th>Typical Variation</th>
<th>Bottleneck</th>
<th>Rebuilding</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Generation 1</td>
<td>Generation 2</td>
<td>Generation 3</td>
</tr>
<tr>
<td>1. Dark Blue</td>
<td>10</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>2. Light Blue</td>
<td>10</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>3. Orange</td>
<td>10</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>4. Red</td>
<td>10</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5. White</td>
<td>10</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>6. Light Green</td>
<td>10</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>7. Dark Green</td>
<td>10</td>
<td>14</td>
<td>17</td>
</tr>
<tr>
<td>8. Purple</td>
<td>10</td>
<td>18</td>
<td>15</td>
</tr>
<tr>
<td>9. Yellow</td>
<td>10</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>10. Black</td>
<td>10</td>
<td>7</td>
<td>8</td>
</tr>
</tbody>
</table>
Conceptual Reasoning
Systems

Elements of a system must all function correctly, or the system will break down.

When one element of a system is at risk, the entire system is at risk.

Elements of a system must all operate in appropriate balance and proportion.
Problem Definition
Format for Problem Definition

What's the Problem?

Write the class consensus problem definition in the box below:

Class Problem Definition:

How can we...

In a way that...

Issues

Constraints
Problem Resolution
Criteria-Based Decision Making

Sample Problem Resolution Grid

*Problem Definition:* How can we create a self-sustaining model black-footed ferret habitat in a way that minimizes contact with home owners and helps ranchers?

**PROBLEM RESOLUTION GRID**

*Instructions:* List the criteria for a good problem solution in the left-hand column. List your options across the top row (only use the number of rows necessary). Next, rate how well each solution option addresses the different criteria using a 3-point scale, in which 1 is *Matches Very Well* and 3 is *Matches Very Poorly*. Total the ratings for each solution option.

<table>
<thead>
<tr>
<th>Solution Options</th>
<th>Provide Protected Area for Prairie Dogs</th>
<th>Vaccinate Black-Footed Ferrets</th>
<th>Relocate Prairie Dogs to National Park Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-Sustaining Model</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

*Problem Resolution Grid*
Culminating Activities

**Requirements**
- To complete this project, we want:
  - Prairie dogs
  - Grasses
  - Water
  - Open land/No human interference
- The ranchers want:
  - Land
  - No prairie dogs
  - Grass
- The general population wants:
  - Land
  - To be able to work on the land

Present their Model

**Newspaper Editorial**

From: Mitchell Ladner, Fish and Wildlife (mladner@email.us.fw.gov)
Subject: Reintroduction Effort—Letter to Editor for The Coloradoan
Date:
To: Black-Footed Ferret Recovery Reintroduction Team (bffrt@email.us.fw.gov)

I have recently learned about your efforts to preserve the black-footed ferret, and I understand you are working on creating a reintroduction site model based on the Fort...
## Presentation Rubric

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Exemplary</th>
<th>At Standard</th>
<th>In Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visuals</td>
<td><em>Visuals are relevant and add to the viewer’s understanding of the topic</em></td>
<td><em>Visuals are related to the topic</em></td>
<td><em>Visuals are not relevant or nonexistent</em></td>
</tr>
<tr>
<td>Use of Information</td>
<td><em>Information is accurate, and detailed; shows understanding of complex ideas</em></td>
<td><em>Information is accurate and is sufficiently detailed</em></td>
<td><em>Information is inaccurate or vague</em></td>
</tr>
<tr>
<td></td>
<td><em>Information is relevant to assignment and is of high quality</em></td>
<td><em>Information is sufficient and generally relevant</em></td>
<td><em>Information is insufficient and/or irrelevant</em></td>
</tr>
<tr>
<td>Use of Sources</td>
<td><em>Information is relevant to assignment and is of high quality</em></td>
<td><em>Gets information from correct number of relevant sources</em></td>
<td><em>Gets information from irrelevant, low-quality sources</em></td>
</tr>
<tr>
<td></td>
<td><em>Identifies and discusses bias in own data</em></td>
<td><em>Identifies bias at the most basic level</em></td>
<td><em>Does not discuss possible bias</em></td>
</tr>
<tr>
<td>Presenter Quality</td>
<td><em>Uses conversational tone and obviously understand material thoroughly</em></td>
<td><em>Speaks from notes or memory using a comfortable tone; shows basic understanding</em></td>
<td><em>Reads from notes and shows little or no understanding</em></td>
</tr>
<tr>
<td></td>
<td><em>Poised and confident</em></td>
<td><em>Generally poised and confident</em></td>
<td><em>Appears indifferent, anxious, or nervous</em></td>
</tr>
<tr>
<td></td>
<td><em>Answers questions clearly and thoroughly</em></td>
<td><em>Responds to most questions with clarity</em></td>
<td><em>Does not know answers to questions</em></td>
</tr>
<tr>
<td>Collaboration</td>
<td><em>Shares time equitably with colleagues</em></td>
<td><em>Shares time but runs over or takes others’ points</em></td>
<td><em>Runs over time and/or makes other presenters’ points</em></td>
</tr>
<tr>
<td>(If applicable)</td>
<td><em>Listens respectfully when not speaking</em></td>
<td><em>Listens most of the time</em></td>
<td><em>Does not listen, whispers during other presentations</em></td>
</tr>
<tr>
<td>Overall</td>
<td><em>Presentation is well-organized and is structured to be interesting</em></td>
<td><em>Presentation is organized and fulfills all aspects of the assignment; organization is logical</em></td>
<td><em>Presentation is not organized and does not fulfill all aspects of the assignment</em></td>
</tr>
<tr>
<td>Presentation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Reflective Moment: Metacognition

- Scientists tend to be devoted to the areas they study. Why would some degree of passion or devotion be necessary to the recovery of the black-footed ferret?...What happens when passion gets in the way of seeing all perspectives on the problem?
Reflective Moment: Thinking about Systems

- What are some negative consequences of an unbalanced system? What are some possible consequences of having the system go out of balance?
Problem Narrative: The Storyline for *Ferret It Out*

The direction of a Problem Based Learning unit is decided through the questions students ask. To some extent, this is made manageable by the structure of the opening scenario presented during Problem Engagement. The opening scenario is carefully designed to point students in the direction of some predictable questions. For example, it would be hard to avoid asking why the black-footed ferret is endangered, what would constitute an ideal habitat, or why the “human climate” is an issue. The narrative below and the lesson plans in this unit respond to these more predictable questions and address other desirable learning outcomes. They also provide a helpful guide for teachers new to PBL.

Experienced PBL teachers are encouraged to use this unit as a framework, selecting lessons that fit the students’ questions (and, as above, many should fit) and adding other lessons to address other questions.

**Problem Engagement**

The students are in the stakeholder role of members of the Black-Footed Ferret Recovery Reintroduction Team (BFFRT). They are tasked with creating a model habitat for the black-footed ferret using Fort Collins, Colorado, as a test site. The team receives a memo from their boss complaining that interest in the black-footed ferret is waning. Attached to the memo is a newspaper with an article about the black-footed ferret that validates those fears. (While the team members probably will not recognize it yet, a majority of the other articles in the newspaper also connect to the problem of reintroducing the black-footed ferret, making this newspaper a useful touchstone throughout the unit.) The team must research the critical elements necessary for successful reintroduction of black-footed ferrets, create a model for reintroduction, and give their presentation to members of the BFFRT Project Oversight Committee.

**Key Questions to Answer**

- Why do black-footed ferrets need to be reintroduced?
- What is the Black-Footed Ferret Recovery Reintroduction Team, and what is its goal?
- What are the critical habitat elements needed for successful reintroduction?
- What, if anything, needs to change about the test site before reintroduction can begin?
- What needs to be considered to account for possible changes to the black-footed ferret as a result of the genetic bottleneck?
- What needs to be included in the model?

**Inquiry and Investigation**

Students research the various learning issues associated with the problem. As they work, they will begin to gain a greater understanding of the genetic fragility of the black-footed ferret and the complex ecosystem in which it lives. During this phase of the problem, students could participate in an optional simulation modeling a genetic bottleneck, as well as a math exercise estimating the number of prairie dogs and acreage required to support the recovering black-footed ferret population.

The need for a substantial prairie dog population opens the door to another dimension of the problem, euphemistically referred to in the opening scenario as the “human climate.” Ranchers are not fond of prairie dogs because they believe prairie dogs interfere with cattle grazing. Students have a chance to test this belief through their research. Natural intruders such as disease or invasive prairie grass threatening the prairie dogs become yet another dimension of the problem.

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**the natural storyline that follows from the first question on the Learning Issues Board**
# Learning Issues Board

<table>
<thead>
<tr>
<th>What do we know?</th>
<th>What are our Learning Issues?</th>
<th>What is our Action Plan?</th>
</tr>
</thead>
</table>

The questions from the first class create the first steps down the path.

**What will the students learn as a result of their research?**

**What happens next?**
<table>
<thead>
<tr>
<th>What do we know?</th>
<th>What are our Learning Issues?</th>
<th>What is our Action Plan?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1 Instruction:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prioritize the Questions!</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Begin and End Each Day with the Learning Issues Board</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Engagement

I found that this ferret unit really made me interested in science and the world! It made me eager to come to science class every day!

Let us be creative.
This was something real people are working on and some of us got pretty passionate about it.

Gave us a modern, real-life topic, allowed us to find realistic solutions that could make a difference.

It was an actual problem to solve. You couldn’t just turn on the computer and find the answer.
Helped me realize how we solve problems today in the adult world. I learned that not everything can be fixed with duct tape.

It actually challenged us to think and solve problems.
Self-Directed Learning

It was fun to be able to have control of a solution and think for myself. Learning about the human side of it all helped me think deeply.

You don’t feel like you are learning but you are, you also remember the important parts better than by just studying. We didn’t have to purposely memorize everything we learned but soaked up the information so we could solve the problem.
Comprehension

It was **deeper** than just learning from the textbook. It **helped me understand** interactions in ecosystems better. I also liked how the problem led to learning about other things, like niches.

We were **learning two things** without knowing it. Everything we learned was connected and easy to understand.

I learned how there are many **different points of view**, it got me to think.
PBL Resources

See the You Tube Walk Through Videos:

A Walk Through...
A Final Appeal
Ferret it Out
Hull House
Excluded!
Black Death

http://www.rfwp.com

Tuesday, July 2, 13
All it Takes to become an Expert is 10,000 Hours of

- Practice
- Practice
- Practice
Let it be known, early on, that there are deep mysteries, and profound paradoxes, ... Teach at the outset, before any of the fundamentals, the still imponderable puzzles...that there are some things going on in the universe that lie beyond comprehension, and make it plain how little is known. ...Teach that.

(Thomas, 1983, p. 151-2)