Problem Based Learning
What is problem-based learning

- Problem-based learning is a system for organizing portions of a school's curriculum around ill-structured problems that help students simultaneously acquire new knowledge and experience in solving problems.
Problem-based learning results

- **Engage** - Define and investigate a research question or problem.
- **Inquire and Investigate** - Access, process, and apply information through a variety of resources including the use of current technology, i.e., Internet.
- **Evaluate and Justify** - Interpret results; develop solutions for real-world application.
- **Communicate** - Information, conclusions and personal responses.
After the Students are Introduced to the Problem

- Learning? Students divide issues into "facts" and "opinions."
- Students form research teams around the issues.
- Students review what they know, and, more importantly, what they don't know.
- Students decide which topics will be tackled by individual team members based on talent or interest and which issues will become the task of the group at large.
- Teams develop a research plan to study their issue.
After Students are introduced to the problem:

- Questions they consider may include:
  - Are you sure of the "facts"?
  - What else do we need to know?
  - Where can we find the information that we need?
  - When can we get this information?
  - How will we get this information?
  - How can we evaluate and justify this information?
After Students are introduced to the problem:

- The class analyzes the feasibility of the individual research plans and investigates a practical application of a class research study.
- Teams conduct considerable research, largely via Internet, as teams challenge each other's findings.
- Students dismiss nondocumented information as unreliable and concentrate on supportable issues.
- Students massage these supportable issues in a final class research study.
After Students are introduced to the problem:

- Individual teams complete tasks as the research continues.
- Students reconvene as a class and determine if all of the research issues have been resolved.
- Students attach old concepts to new ideas as they progress through the problem.
After Students are introduced to the problem:

• Questions they consider may include:
  – How are we doing?
  – What's working?
  – What is not working?
  – How do we know?

• Students communicate their study results to a larger audience.
Find the Problem:

- The study is planned and directed by the students and facilitated by their teacher.
- Students collect data and analyze and compare it with other datasets.
- Students use a problem-based learning (PBL) strategy.
- Students use technology (i.e., Internet, word processing, interactive charts and graphs, etc.) in their work.
- Students work in cooperative learning groups simulating a research mode in which scientists engage.
Meet the Problem: The research question is ill-structured in nature and must be thoroughly analyzed by investigation, inquiry and experience before it can be solved.
Frame the Problem: Students will need to collect the "missing components" - information not provided but necessary for a viable solution. As part of this process, students will gather data, hypothesize, prioritize, organize and analyze through methods that include:

- Relating "hunches" and determining fact from opinion.
- Assessing what is known by critical analysis.
- Developing an action plan that is a product of many minds.
- Gathering information/organizing/sharing information from various special focus g
Frame the Problem

• Generating preliminary solutions based on information interpreted in action groups through cooperative learning strategies such as jigsaw.
• Revisiting the problem and analyzing solutions from various focus groups critically to determine viability.
• Assessing/Debriefing to make certain that all special interest groups are heard.
• Solving the problem appropriate to conditions of problem - cooperation, compromise, common sense!
Characteristics of Problem-Based Learning

Problem-based learning requires an artful combination of the following components. A skilled teacher/facilitator recognizes the value of each step and takes the time for proper preparation, assimilation, involvement, and development of the outcomes.
Characteristics identified by W. J. Stepien

- **Reliance on problems to drive the curriculum** - The problems do not test skills; they assist in the development of the skills themselves.
- **The problems are truly ill-structured** - There is not meant to be one solution, and as new information is gathered in a reiterative process, perception of the problem, and thus the solution, changes.
- **Students solve the problems** - Teachers are the coaches and facilitators.
- **Students are only given guidelines for how to approach problems** - There is no one formula for student approaches to the problem.
- **Authentic, performance based assessment** - is a seamless part and end of the instruction.
Problem-Based Learning -

What Are the Benefits?
Using PBL as a strategic tool in the classroom entails the development of the teacher as facilitator of learning, the class as strategic learners and problem solvers, and the district as an innovator andembracer of productive, progressive education. Effective PBL strategies will result in the following benefits for the teacher, the classroom, and the district:
Motivation

• PBL makes students more engaged in learning because they are hard wired to respond to dissonance and because they feel they are empowered to have an impact on the outcome of the investigation.
Relevance and Context

- PBL offers students an obvious answer to the questions, Why do we need to learn this information?" and "What does what I am doing in school have to do with anything in the real world?
Higher Order Thinking

- The ill-structured problem scenario calls forth critical and creative thinking by suspending the guessing game of, What's the right answer the teacher wants me to find?
Learning How to Learn

- PBL promotes metacognition and self-regulated learning by asking students to generate their own strategies for problem definition, information gathering, data-analysis, and hypothesis-building and testing, comparing these strategies against and sharing them with other students' and mentors' strategies.
Authenticity

• PBL engages students in learning information in ways that are similar to the ways in which it will be recalled and employed in future situations and assesses learning in ways which demonstrate understanding and not mere acquisition. (Gick and Holyoak, 1983).
Benefits

• Problems encountered resemble the nature of problems encountered in the real world. Problems provide clues, context, and motivation; they are the maps which guide learners to useful facts and concepts.
• Since the problem cannot be clearly approached on the first encounter, it becomes a challenge, promoting creative thinking and developing organizational skills.
• Prior knowledge provides a foundation for establishing a framework for extending learning opportunities for all parties involved in the process.
• Misconceptions about teaching and learning, curriculum, math and science instruction, and learner content level understandings are revealed.
• The legitimacy of the group's as well as the individual's learning goals are established.
Benefits

• The process empowers the group (student and educator alike at their own level) to assume responsibility for directing learning, defining and analyzing problems, and constructing solutions.
• Transfer of knowledge and skills is enhanced through the use of multiple tasks and problem concepts to help form functional abstractions.
• Participants are instructed in becoming responsible members of a learning community by active participation in the PBL process.
• The PBL process models a strategy that can become a foundation for a life skill- vocational training for future problem solvers.
• Common understandings and unexamined assumptions are articulated district-wide as the PBL process is employed - providing direction and opportunities for staff development activities for the future.
Very simply stated, PBL develops students who can:

- Clearly define a problem from an ill-structured situation.
- Establish and prioritize learning issues, separating fact from opinion.
- Develop alternative hypotheses through group brainstorming and mind mapping.
- Access, evaluate, and utilize data from a variety of sources - electronic resources playing a major role.
- Alter initial hypotheses after research and evaluation of new information.
- Develop clearly stated solutions that fit the problem and its inherent conditions, based on sound research and logical interpretation of this information in a group setting.
How does PBL compare with other instructional approaches?
Considerations

- role of the problem
- role of the teacher
- role of the learner
Problem-based learning begins with the introduction of an ill-structured problem on which all learning centers. Teachers assume the role of cognitive and metacognitive coach rather than knowledge-holder and disseminator; students assume the role of active problem-solvers, decision-makers, and meaning-makers rather than passive listeners.
Problem-Based Learning causes a shift in roles
Teacher as Coach

- Models/coaches/fades in:
- Asking about thinking
- Monitoring learning
- Probing/ challenging students' thinking
- Keeping students involved
- Monitoring/ adjusting levels of challenge
- Managing group dynamics
- Keeping process moving
Student as active problem solver

- Active participant
- Engaged
- Constructing meaning
Problem as initial challenge and motivation

- Ill-structured
- Appeals to human desire for resolution/stasis/harmony
- Sets up need for and context of learning which follows
Problem-based learning has as its organizing center the ill-structured problem that ... 

- is messy and complex in nature 
- requires inquiry, information-gathering, and reflection 
- is changing and tentative 
- has no simple, fixed, formulaic, right solution
Examples of ill-structured problems used in PBL

You are

- a scientist at the state department of nuclear safety. Some people in a small community feel their health is at risk because a company keeps thorium piled above ground at one of their plants. What action, if any, should be taken? Summer Challenge 1992, IMSA

- a consultant to the Department of Fish and Wildlife. A first draft of a plan for the reintroduction of wolves to Yellowstone has received strong, negative testimony at hearings. What is your advice regarding the plan? John Thompson, Ecology, IMSA

- a science advisor at NASA. A planet much like the earth has experienced massive destruction of elements of its biosphere. What is causing the destruction of plant life? Can new plants from earth be successfully introduced to help save the planet's environment?
• You are
  – a thirty-six year old single working mother with a five year old daughter. Upon your husband's death, you receive $20,000 in worker's compensation and $10,000 in stock option shares. How can you invest this money so that by your daughter's 18th birthday, its growth is maximized? LuAnn Malik, Community College of Aurora, Aurora, CO
  – a member of President Truman's Interim Committee. What advice will you give the President to help end the war in the Pacific? An atomic bomb has just been detonated at Los Alamos. Bill Stepien, American Studies, IMSA
  – invited to participate in a special session of your school board to determine whether Huckleberry Finn should be taught in your school district given its inclusion on a state censorship list. Ed Plum, American Literature, District #214, Barrington, IL
  – a stockholder of a major oil refinery in Louisiana which has mined oil from wetlands in the southern part of the state. You have received pressure from publicity about the wetlands to make it property of the federal government so that it can be protected. What will you do? Christine Vitale, 4-5 multi-grade, Arlington Heights, IL
Short Cut to Problem-Based Learning:

This is a simplified model. Note that it is an iterative model. Steps two through five may be conducted concurrently as new information becomes available and redefines the problem. Step six may occur more than once—especially when teachers place emphasis on going beyond "the first draft."
1. Present the problem statement. Introduce an "ill-structured" problem or scenario to students. They should not have enough prior knowledge to solve the problem. This simply means they will have to gather necessary information or learn new concepts, principles, or skills as they engage in the problem-solving process.
2. List what is known. Student groups list what they know about the scenario. This information is kept under the heading: "What do we know?" This may include data from the situation as well as information based on prior knowledge.
3. Develop a problem statement. A problem statement should come from the students' analysis of what they know. The problem statement will probably have to be refined as new information is discovered and brought to bear on the situation. Typical problem statements may be based on discrepant events, incongruities, anomalies, or stated needs of a client.
4.

- List what is needed. Presented with a problem, students will need to find information to fill in missing gaps. A second list is prepared under the heading: "What do we need to know?" These questions will guide searches that may take place on-line, in the library, and in other out-of-class searches.
5. List possible actions, recommendations, solutions, or hypotheses. Under the heading: "What should we do?" students list actions to be taken (e.g., questioning an expert), and formulate and test tentative hypotheses.
6.

- Present and support the solution. As part of closure, teachers may require students to communicate, orally and/or in writing, their findings and recommendations. The product should include the problem statement, questions, data gathered, analysis of data, and support for solutions or recommendations based on the data analysis.
Creating the ill-structured Problem:

- Students need more information than is initially presented to them. Missing information will help them understand what is occurring and help them decide what actions, if any, are required for resolution.
- 2. There is no right way or fixed formula for conducting the investigation; each problem is unique.
- 3. The problem changes as information is found.
- 4. Students make decisions and provide solutions to real-world problems. This means there may be no single "right" answer.
PBL Socratic Questioning
The Role of Questioning in Problem-Based Learning

The use of open-ended, probing questioning when initiating and perpetuating inquiry into the ill-structured problem is a key component to the success of the PBL experience. A strategy known as Socratic questioning is designed to elicit a wealth of ideas and facts from any group. When using Socratic questioning with younger audiences, considerable patience, coupled with a warm and inviting classroom atmosphere is essential.
Socratic questioning promotes synthesis of information into discernible categories of "fact" and "opinion." This strategy will attempt to:

- raise basic issues.
- probe beneath the surface.
- pursue problematic areas of thought.
- help participants discover the structure of their own thoughts.
• help participants develop a sensitivity to clarity, accuracy, and relevance.
• help participants arrive at judgments based on their own reasoning.
• helps participants note claims, evidence, conclusions, questions at issue, assumptions, implications, consequences, concepts, interpretations, points of view, . . . all considered to be the elements of thought. (Paul, 1993)
While it is difficult to establish a concrete format for questioning within a variety of circumstances, Socratic questioning includes a taxonomy of questions that may be utilized diagnostically as the teacher/facilitator moderates discussion and verbal inquiry. The categories are as follows:

- Clarification
- Probe assumptions
- Probe reasons and evidence
- Reveal differing viewpoints and perspectives
- Probe implications and/or consequences
- Used for responding to questions
Participants involved in the PBL experience must be willing to:

- listen carefully to each other, and take the issues and comments seriously.
- thoughtfully reflect on the issues and look beneath the surface.
- look for reasons, evidence, assumptions, inconsistencies, implications and/or consequences, examples or counter-examples, and respect other perspectives.
- seek to differentiate knowledge from beliefs (facts from opinions).
- maintain a "healthy" level of skepticism, or play "devil's advocate."
- remain open-minded, and not allow themselves to "shutdown" when the views of others do not match their own.
The taxonomy of Socratic questions, created by Richard Paul, is not a hierarchy in the traditional sense. The categories build upon each other, but they do not necessarily follow a pattern or design. One question's response will lead into another category of questioning not predetermined by the teacher/facilitator. In keeping with the PBL philosophy, this aspect of the model is most conducive! The role of the skilled teacher/facilitator is to keep the inquiry "train on track," but, also, to allow the students to "travel to a viable destination" of their own design.
Questions thatProbe Reasons and Evidence
Questions of Clarification

• What do you mean by _____?
• What is your main point?
• How does _____ relate to _____?
• Could you put that another way?
• Is your basic point _____ or _____?
• What do you think is the main issue here?
• Let me see if I understand you; do you mean _____ or _____?
• How does this relate to our problem/discussion/issue?
• What do you, Mike, mean by this remark? What do you take Mike to mean by his remark?
• Jane, can you summarize in your own words what Richard said? . . . Richard, is this what you meant?
• Could you give me an example?
• Would this be an example, . . .?
• Could you explain this further?
• Would you say more about that?
• Why do you say that?
Questions that Probe Assumptions

- What are you assuming?
- What is Jenny assuming?
- What could we assume instead?
- You seem to be assuming _____. Do I understand you correctly?
- All of your reasoning depends on the idea that _____. Why have you based your reasoning on _____ instead of _____?
• You seem to be assuming ______. How do you justify taking that for granted?
• Is that always the case? Why do you think the assumption holds here?
• Why would someone make that assumption?
Questions that Probe Reasons and Evidence

- What would be an example?
- How do you know?
- Why do you think that is true?
- Do you have any evidence for that?
- What difference does that make?
- What are your reasons for saying that?
- What other information do you need?
- Could you explain your reasons to us?
- Are these reasons adequate?
• Why do you say that?
• What led you to that belief?
• How does that apply to this case?
• What would change your mind?
• But, is that good evidence for that belief?
• Is there a reason to doubt that evidence?
• Who is in a position to know that is true?
• What would you say to someone who said that ____?
• Can someone else give evidence to support that view?
• By what reasoning did you come to that conclusion?
• How could we find out if that is true?
Questions about Viewpoints or Perspectives

- *What are you implying by that?*
- When you say _____, are you implying _____?
- But, if that happened, what else would happen as a result? Why?
- What effect would that have?
- Would that necessarily happen or only possibly/probably happen?

*The term "imply" will require clarification when used with younger students.*
• What is an alternative?
• If _____ and _____ are the case, then what might also be true?
• If we say that _____ is ethical, how about _____?
Questions that Probe Implications and Consequences

- How can we find out?
- What does this question assume?
- Would _____ ask this question differently?
- How could someone settle this question?
- Can we break this question down at all?
- Is this question clear? Do we understand it?
- Is this question easy or hard to answer? Why?
• Does this question ask us to evaluate something? What?
• Do we all agree that this is the question?
• To answer this question, what other questions must we answer first?
• I'm not sure I understand how you are interpreting this question. Is this the same as _____?
• How would _____ state the issue?
• Why is this issue important?
• Is this the most important question, or is there an underlying question that is really the issue?
Brainstorming
Mind maps (also known as concept maps) and/or know/need to know charts will benefit students in the following ways:

- "Capture" ideas as they are generated
- Organize these ideas in a meaningful manner
- Prioritize ideas generated from class discussion
- Separate "fact" from "opinion"
- Help to establish learning issues and develop focus areas for group work
Rules for brainstorming generally include the following:

- Establish a "starting point" based on the "ill-structured" problem (In this case, "Prairie Restoration/Planting" may be the logical choice.)
- Students brainstorm ideas surrounding the starting point.
- A recorder records responses without comment.
- Items will be categorized and grouped by group consensus (Format A).
- Items will be analyzed as "fact" or "opinion" through group consensus (Format B).
Sample Concept Map

Native Americans
Settlers
Farming

People

Fires

Animals

Prairie

Plants

Prairie Dog

Bison

Flowers

Grass

Native but mostly gone
<table>
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<th>What Do We Know?</th>
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KWL as a Pre-Assessment Tool

The KWL strategy is a comprehension device successfully utilized in reading classrooms for some time. For the purpose of pre-assessment, the traditional KWL strategy will be modified. The transfer of this strategy from Language Arts to the Science classroom as a research Plan of Action organizer is a positive movement. As we place students in the role of Student Researcher, it is wise to provide such a tool to aid in the construction of a knowledge base. It is, furthermore, an opportunity for the teacher to assess the prior knowledge and abilities with which the student(s) enter the classroom.
Stage 1

- A simple Pre-Assessment tool will precede this KWL implementation. Student will submit the Pre-Assessment for informal evaluation and maintain the document in their portfolios for evidence of their progress throughout the unit.
Stage 2

- The implementation of KWL as a Journal option is a powerful strategy. As the student writes, metacognition is activated. Students are more apt to THINK as they write. The teacher, as facilitator, will present the problem and document student responses to the KWL on large newsprint or the chalkboard.
Traditional KWL

- **K** - What do the students already **KNOW** about the topic? (Brainstorm the products of the Pre-Assessment tool, allowing all students a voice in the process. Accept all responses.) When the item generating "energy" is depleted, save the information and create three columns on the chalkboard or other appropriate place.

- **W** - What do the students **NEED** to know about the topic? (Mind Mapping is a strategy that may provide significant assistance as students attempt to separate fact from fiction.) Proceed to separate "facts" from "opinion" and place the facts in the "Know" column and the opinions in the "Need to Know" column.

- **L** - What will the students **LEARN** or hope to learn (do and hope to do) about the topic? (Project Rubrics) These "learning issues" will evolve as the Mind Mapping, or other strategy, reveals "clusters" of information and/or skills needed to form the resolution to the problem. Associated with the content based learning issues are the considerations of technology and cooperative group behavior.
Stage 3

- Implementation of the Plan of Action, research, refinement, and resolution.
Mind Mapping

A Mind Map is a graphic organizer, which will ease some of the "messiness" associated with the Engaged Learning process. Utilizing this strategy in conjunction with KWL, the skillful facilitator can help Student Research Teams separate fact from opinion, isolate key components for refining the "ill-structured problem", and develop a Plan of Action.
1. Mind maps can be modeled to the entire class using some generic topic such as "Natural Area". (See example below)

2. Mind maps can (and will) become messy. Note obvious overlaps below. Image a continuation of this map with non-human enemies eating a specific plant, but, in turn, providing a valuable assist to the plant as a mode of seed dispersal. Many expansion possibilities exist.

3. Students can use mind maps to define research sub-topics for individual Student Research Team members, facilitating team Action Plans.

4. Mind maps provide structure for the learning experience and should be carefully assessed by the Teacher/Facilitator.
Research Plan

After completing the initial brainstorming, students meet in cooperative learning groups to plan their research strategy. An effective way to develop synergy within the classroom setting is to have individual groups of students determine which of the "learning issues" they would like to pursue. Assuming that there are multiple issues within the classroom, each group will have at least one issue to research. It is all right to have two groups independently researching the same issue and collaborating at the end to meld the best information into a reliable component.
The research plan will determine

- The role(s) of each group member (coordinator, recorder, reporter, etc.).
- The task(s) of each group member (refine research directions, establish specialty areas, etc.).
- How students will gather information about learning issues established previously through research.
- How students will formulate and test hypotheses.
- How students will rethink and/or revamp initial ideas to reflect newfound knowledge and understanding.
Throughout the work, students will keep notes in their journals. The action plan, when completed, will lead to final preparation and execution of reporting study results.
Student Research Plan

Group 3 Preliminary Work Plan Linda Lynn, Scott Smith, John Thomas, Jenny White
• John - Planning
  – Complete Know/Need to Know
  – Brainstorm research questions
  – Develop work plan
• Jenny - Review requirements & assign tasks
  – Look over "Prairie Research Links"
  – How do we do a quadrat study? When?
  – What do we have to publish?
  – How will we be assessed??
  – What resources are available?
  – Do we want to collaborate with other students?
  – How will we report our progress?
• Linda - Do assigned tasks. Check from time to time --
  – What we have learned
  – What do we still need to do? to know?

• Scott - Analyze our results. Prepare online publications
  – Publish data online
  – Write report
  – Publish report online
Designing Scenarios

- Can come from anywhere — Literature, TV, news, newspapers
- Consider
  - A loosely structured case or prompt embedded with links to desired outcomes
  - Small group collaborative learning
  - A one sentence case can drive the curriculum for weeks
  - Use of hands-on materials for hypothesis testing
  - Learning is open
Resources

• Center for Problem-Based Learning from Illinois Math and Science Academy
  http://www.imsa.edu/team/cpbl/cpbl.html

• Exploring the Environment - Goals and Objectives of PBL
  http://www.cotf.edu/ete/teacher/tprob/teacherout.html
• South Dakota State University Assessment of PBL Learning
  http://edweb.sdsu.edu/clrit/learningtree/PBL/webassess/studentNclasses.html

• University of Delaware - Center for Teaching Effectiveness
  http://www.udel.edu/pbl/cte/jan95-what.html
- Air Quality Curriculum Products
- Tutorial on Problem based learning
- Nature, Problem-based learning resources for teachers
• Problem based learning scenarios
  http://www.usc.edu/hsc/dental/ccmb/usccsp/mainpgscen.html

• Visual of the PBL Process

• Two web-based PBL situations:
  – http://www.mason.gmu.edu/~pnorton/Zerkon.html
  – http://www.imsa.edu/team/cpbl/whatis/Bisonproj/pblacknowl.html
• The Chalk Tray
  http://kancrn.kckps.k12.ks.us/Harmon/brbaughm/pbgoals.html

• Instep Instructional Designs
  http://www5.cet.edu/designs/ddennis/tprint.html