PROBLEM-BASED LEARNING (PBL)

PBL Quick Facts:

- **What is PBL? Is it a new methodology?** PBL is not a new model of instruction. Plato and Socrates required that their students think, retrieve information for themselves, search for new ideas and debate them in a scholarly environment. However, this process differs from the teacher-dominated approach used in most educational settings.

- **Where did PBL come from?** PBL was officially adopted as a pedagogical approach in 1968 at McMaster University, a Canadian medical school. (Neufeld & Barrows, 1974), because students were unable to apply their substantial amount of basic scientific knowledge to clinical situations.

- **How Does it Work?** Students in small groups investigate and analyze problems/scenarios. Using an organizer process of; 1) identifying the FACTS in the problem/scenario; 2) generating (un-criticized) their IDEAS about the scenario/problem and identifying just "what is the problem?"; 3) finally identifying the things they have to LEARN about - in order to test their hypotheses (ideas).

- **Why is this an effective approach?** The use of this three step inquiry-organizer helps students become familiar with a scientist's reasoning process, to fill the gaps in their own knowledge base, and to use their newly acquired knowledge to refine or discard their ideas thus generating a whole new set of LEARNING NEEDS. This model has been successfully applied to science instruction at all grade levels.

PBL places students in small groups and provides a means by which they can investigate real problems. According to Fincham et al. (1997), **"PBL does not present a new curriculum but rather the same curriculum through a different teaching method**," (p. 419).

How is problem-based learning different from project-based learning?
Project-Based Learning: Teacher A has her class design and build a city by the end of the semester. The task is defined for them at the beginning with the inquiry bounded. They discuss and explore various aspects of cities, architecture, sewer and other systems etc. Students identify what they believe are the most effective

ways to build their city within the boundaries they are given in order to complete their project.

Problem-Based Learning: Teacher B has a city designed and built by students as her final outcome the students may not know what that outcome is. The inquiry is very open allowing the students to discover aspects that may not have been apparent. She introduces various scenarios/problems to her students throughout the semester. Each scenario deals with a different aspect of the city. An example would be sewage systems. Given a scenario related to sewage, students identify the FACTS, brainstorm IDEAS about what the problem really is and what they think about the situation. The LEARNING NEEDS they identify for themselves may take them into: How various systems work, alternative sewage systems, environmental issues, the role that soil plays in waste disposal, the impact on the water supply, waste disposal legislation, debates about the pros and cons of public/private operations, water contamination and/or purification etc. generating new FACTS, refining IDEAS and generating new LEARNING NEEDS. The next scenario/problem may take them in-depth into different aspects of water purification systems, building on the knowledge they gained in the previous scenario/problem. At the end of the semester, the city is built, and in-depth research has been done on each piece of the city's infrastructure.

How do I safeguard the integrity of the process? The integrity of the process depends to a great extent on the groups themselves. Groups are kept small, approximately 5 students and a facilitator. At the beginning of the process, group norms are set by the students in the group. Norms include **but are not limited to**: Respect for everyone's ideas – no idea is "stupid"; not interrupting someone else while they are speaking; in other words **"what should be OK in this process and what should not be OK – the rules of the game".**

IDEAS are organized and put into a "testable" form (hypothesis). LEARNING NEEDS are prioritized and divided among the group participants. Each group member researches their part and the next day the group meets to discuss and share the new information. Assessments are given to the group as a whole - the sharing of information becomes an imperative and because of this the group becomes a powerful force for mutual dissemination.

What part do hands-on instructional materials and kits play in PBL? Hands-on materials and kits are powerful tools to learn concepts and to test hypotheses in order to refine IDEAS. E.g. a scenario/problem that has a learning need about why a seed won't grow could utilize a kit to test soil samples, or water samples, or a weather study could result. Teachers can anticipate what may be needed so that materials are on hand. In addition, art or the performing arts can be integrated as an outcome; field sketching, clay, botanical drawing, dance, plays, robot building, etc. The process can be as creative for the teacher as for the students.

Problem-Based Learning in Science Classrooms

Students are at the center of learning when teachers implement PBL. First, a problem or scenario is presented to stimulate student interest. Students work in small groups to investigate the problem. With very young children, the teacher may keep the class as a large group for fact-finding, idea generation and learning needs identification. As the process progresses, ideas are challenged by other group members or by the teacher if necessary. The process is cyclical and repeated several times as new information is learned and ideas have been modified to generate new learning needs. It should be noted that solving the problem is not the most important objective, the power of PBL is found within the learning process itself through student-directed inquiry. Scientific facts and concepts are not taught directly, but integrated within the scientific process. Also integrated within the process is reading, writing, vocabulary and if desired, mathematics and a host of other disciplines.

When investigating a PBL scenario, students assume the role of scientist. Effective problems are those that engage student interest and motivate them to probe for deeper understanding of science concepts. Good problems ask students to formulate ideas or judgments based on facts that may be prior knowledge, information given in the scenario, and logic. Problem-based learning usually includes several steps.
The five-step model in the chart below identifies these steps.

1. **Problem is presented and read by group member, while another acts as scribe to mark down FACTS as identified by group.**
2. **Students discuss what is known** (the facts).
3. **Students discuss what they think and identify the broad problem** (brainstorm their ideas and formulate their hypotheses).
4. **Students identify their learning needs** (what they need to learn in order to prove or disprove their ideas).
5. **Students share research findings with their peers, then recycle steps 2-4**

Teachers take on a minimal role when presenting PBL scenarios. They use open-ended questions to foster student metacognitive growth. If necessary, ask questions like: What's going on here? What do we need to know more about? What is your evidence? A wait-time is essential to allow the student to process the information and formulate their ideas – they should not be rushed. As students participate in PBL over time, they become self-directed learners who are able to ask their own questions, and identify what they need to know to continue their learning.

Creating PBL Scenarios

Ideas for PBL scenarios can come from almost anywhere; literature, television programming, news programs or newspapers articles. Wonderful PBL scenarios can be created by changing traditional lessons into problem-based inquiry learning. These lessons should be aligned with the curriculum for your grade level and embedded with desired learning outcomes. When creating or identifying scenarios consider the following components:

- A loosely structured case or prompt embedded with links to desired learning outcomes i.e. standards (national, state or local).
- Small group cooperative learning is best, but find the model that works best for you.
- In the example provided of a dental education case from Malmo, Sweden – the one sentence case drives their curriculum for weeks (see schematic in Appendix).
- Use hands-on kits and instructional materials – to test hypotheses and generate new facts based on scientific experimentation.
- Learning is very open. In the case provided, "Buzz-saw Terror" if students have an idea that the insect is an ant and you as a teacher know it isn't – it's OK if they spend time investigating ants – eventually they are going to find that ants don't build mounds like the one described. When they do, they're back on track and they not only learn about the insect that does build the mound – they also have learned about ants, which may or may not have been a teacher-desired outcome in the first place.

We have included in this packet, a variety of PBL scenarios that have been successfully implemented in science classrooms. Feel free to use them as they are written or change them to meet the needs of your students or your science curriculum. Some of these cases are short and can be completed within 2-3 class sessions, other cases require 1-4 weeks. In some instances, students at different grade levels can use the same case. The beauty of PBL is that students use their prior knowledge when developing ideas and formulating those ideas into hypothesis that can be tested. The advanced level of a high school student will result in a deeper, more complex investigation than would be done by a younger student.

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