Problem-based Learning Lab Lesson Plan

Teacher Introduction:

Problem-based learning (PBL) instruction is designed to provide students with guided experience in solving ill-structured problems. Ill-structured problems have four characteristics: (1) more information is initially available than is needed to understand the problem, (2) the problem definition changes as new information is added to the situation, (3) many perspectives can be used to interpret information is added to the situation, and (4) no absolutely "right" answer exists. By placing your students in the middle of a "mess," you provide them with an opportunity to appreciate the importance of problem finding in the overall problem-solving process, permit them to participate in the reiterative process of problem definition and redefinition, and. effectively help them understand the importance of identifying the problem before adopting a solution. The solution to an ill-structured problem requires the use of both divergent and convergent thinking; therefore, you will prepare your students for the "real world," ill-structured problems that they will encounter outside of school and as adults.

PBL is an active, student-centered process. Your students, not you, are primarily responsible for the learning that takes place in their PBL groups (7-8 students). You, the facilitator, are a guide and coach, not a lecturer or resource. Your principal role is to promote student-centered learning, critical thinking, and appropriate group dynamics within the group. The facilitator does this by posing non-directive questions at appropriate times to encourage analytical thought and aid group process. For example:

Student: The dissolved oxygen (DO) level should be higher at location 3 due to the riffles.
Facilitator: How would you explain that to someone not trained in water monitoring?

Or

Student: Since increases in water temperature reduces the DO level, . . .
Facilitator: If you were challenged, could you produce evidence to support that claim?

Or

Student: So you see, if we consider the increased nitrate levels at location 3 . . .
Facilitator: How does this relate to your original hypothesis about organic effluent?

As the students PBL skills improve, the facilitator's participation is decreased.

Procedure:

Tell the students that they will be participating in a simulation in which they will be students who have discovered a problem while on a field trip. Have the students read the Problem-based Learning Lab Part One only. Guide them to look at the basic problem, known facts, hypotheses, knowledge gaps), which should have been previously drawn on the chalkboard in columns with each of the 3 sites listed below these topics. Ask a volunteer to record information in the appropriate columns as the class begins to tackle the problems using the PBL process (Tufts College's model).

Define the Problem - Identify the basic problem within the scenario:
Why does the water at location 3 smell? Why is the site different from sites 1 and 2? New information often changes the group's perspective on a case, so this step must frequently be revisited.

Fact Finding - Identify the facts presented in the information available.

Generate Hypotheses - Using the given information, the group discusses what could cause these factors and why they would occur. By systematically considering each possibility as you work through the scenario, the group will narrow the field to the most plausible hypotheses.

Exchange Information - Each member of the group has a separate set of experiences, knowledge, and expertise. As the group discusses the scenario, different individuals can offer various pieces of information.

Define Learning Issues - Despite the group's pooled knowledge, some areas will remain undefined. These "knowledge gaps" are areas to be investigated further in the scenario.

NOTE: This process is highly interactive with progress in one area influencing others. Move both backwards and forwards through the different steps at will.

When no further processing can be done through discussion of the Problem-based Learning Lab, Part One, divide the class into small groups to continue the above process using the Problem-based Learning Lab, Part Two. The teacher should allow a student leader to emerge within each group to act as group facilitator. After each group has completed the simulation, have the class discuss the various solutions and summarize what was learned.

Problem-based Learning Lab Part One

The Biology students at Ashland High School monitor water quality of the Jerome Fork watershed. The Jerome Fork flows southeast through Ashland County, Ohio. The headwaters of Jerome Fork are at the confluence of the Orange and Leidigh Mill Creeks, 4 km northwest of the city of Ashland. The Jerome Fork is part of a drainage system that flows into the Ohio River. The students are divided into three monitoring groups, each monitoring a site along Jerome Fork. Site 1, the northern most location, is located at the State Route 58 bridge over the river, site 2 is located at the State Route 42 bridge over the river, and site 3 is located at the County Road 1302 bridge over the river. The land surrounding the three sites on the Jerome Fork is farmland and undeveloped forest consisting primarily of beech, maple, and oak trees. The river slowly moves through the 12 m channel at site 1 at a depth of 0.4 m. At site 2, the river continues its slow pace and 0.4 m depth, but the channel narrows to 10 m. The river bottom at sites 1 and 2 consists of mud over sand. Station 3 is comprised of riffles in a cobble-sand substrate and is 8 m wide and 0.4 m deep. Te site depth and width vary considerably with the seasons, especially during spring floods.

The field trip for this date included not only completing the physicochemical monitoring but also the seasonal macroinvertebrate sampling. Students returning from sites 1 and 2 return to the classroom to complete their laboratory work. The students from site 3 returned to the classroom reporting that their site not only smelled horrible but also appeared to have a red wiggling carpet from shore to shore.

Problem-based Learning Lab, Part Two

The students decided to compare the current and historical data from the three consecutive sites, which were located approximately 1.25 km apart from each other. The students developed the following chart:

Table 1: Physicochemical Water Quality Data for Jerome Fork Sites

	Summer 1977			Fall 1977			Spring 1978		
	1	2	3	1	2	3	1	2	3
D.O. (mg/l)	7.2	7.0	5.2	11.4	11.0	7.3	13.5	13.9	11.3
CO2 (mg/l)	17.0	17.4	27.0	15.7	15.9	23.9	22.5	23.0	25.2
pH	8.0	8.0	7.6	7.6	7.5	7.5	8.4	8.5	8.3
NO3 (mg/l)	1.4	1.4	3.1	1.1	1.0	2.8	1.1	1.1	2.8
Temp. (C)	21.2	21.1	21.0	14.2	14.4	16.4	10.4	10.2	7.4

Date and Site

	Spring 1979			Fall 1979			Fall 1980		
	1	2	3	1	2	3	1	2	3
D.O. (mg/l)	10.0	9.6	8.3	8.2	7.9	6.3	7.9	7.7	4.0
CO2 (mg/l)	11.4	11.6	10.9	11.5	11.6	13.3	8.0	8.0	8.0
pH	8.6	8.5	8.2	8.5	8.5	8.3	8.6	8.5	8.0
NO3 (mg/l)	2.4	2.4	3.0	2.8	2.8	3.1	2.0	2.1	3.4
Temp. (C)	12.1	12.0	14.1	14.9	14.9	16.4	16.0	16.2	17.3

For the biological data, the student records indicate that at sites 1 and 2 mayfly and stonefly larvae, water pennies, and clams have regularly been collected. Numerous individuals of a large variety of fish species have been collected. Planaria, leeches, crayfish, and sideswimmers have occasionally been collected. At site 3, students have observed tremendous numbers of few species (midge fly larvae, rat-tailed maggots, mosquito larvae, and sludge worms) present. Minnows appear to be the only consistent fish present.

The students were appalled by the scene at site 3 on this field trip. The evidence of the physicochemical analysis records combined with the biological data supported their assertion that the presence of the city's sewage treatment plant (STP) was presenting a serious pollution problem in a major drainage system. The city's STP effluent is causing an ecosystem to change from a healthy, clean river to one poor in species and offensive to sight and smell.

Scenarios based on article by James W. Wilkes, American Biology Teacher, Volume 45, No. 8 pp. 415-418 & 423, December 1983.