

Problem Based Learning and GIS: PBL-GIS

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Introduction

As the teachers in this book have discovered, designing effective GIS-based learning opportunities for students requires a new approach to structuring the curriculum, to teaching, and to assessing student learning. The approach used most successfully to teach with GIS is problem based learning (PBL). In PBL, teachers and students integrate concepts and skills from one or more disciplines to investigate a problem (Jones, Rasmussen, and Moffitt 1997). In this chapter we outline a form of PBL customized for use with GIS, called PBL-GIS, and provide concrete strategies to to organize PBL-GIS activities.

What is PBL-GIS?

PBL-GIS is a strategy to organize your curriculum so that you can teach more effectively with GIS. It is the practice of structuring what you teach around a series of 'problems.' Problems are used to frame, focus, organize, and stimulate learning. Students, working alone or in small groups, investigate these problems using a variety of research tools and technologies, particularly GIS. PBL-GIS mirrors the five skills of geography included in *Geography for Life: The National Geography Standards 1994*. These skills are explained in the graphic on this page.

Five Skills of Geography	PBL-GIS
Ask geographic questions.	Select a problem with a geographic (spatial) focus and express it as one or more inquiry questions. Organize a research plan.
Acquire geographic information.	Collect primary data from observations, field work, GPS. Locate existing secondary data sets. Digitize maps.
Organize geographic information.	Organize data into spatial database/GIS; create GIS, select and design appropriate forms of maps and graphs; explore geographic relationships.
Analyze geographic information.	Conduct queries, explore data, analyze, synthesize, evaluate, and explain GIS. Make inferences and draw conclusions.
Answer geographic questions.	Summarize findings, offer possible solutions to problem, formulate valid generalizations from results of geographic inquiry. Reflect on learning and present results.

How Does PBL-GIS Work?

Approach

There are many approaches to PBL-GIS. They range from simple to complex and from very open ended to fairly detailed and structured. Two models are explained in the next section, one simple and one more complex, each with a more or less active and directive role for the teacher. PBL-GIS is a unique vision of learning. The approach you choose to take depends upon your teaching style, level of comfort with GIS, and students. PBL-GIS requires new roles and responsibilities for both you and your students.

Role of the Teacher in PBL-GIS

In PBL-GIS, students teach themselves. The classroom is truly 'student centered.' Your role becomes that of a facilitator, a coach, a guide, and a resource person, advising and supporting

students in their research inquiries. That does not mean that you can become uninvolved. In many ways, your classroom role becomes more important in PBL-GIS than in other forms of classroom management. You will need to model research skills, problem solving strategies, and how to use GIS, as well as other research tools and techniques in a very direct fashion.

Role of Student in PBL-GIS

PBL-GIS makes students take on new roles as well. They direct their own studies and 'learn to learn' as they work to investigate and solve problems. In this process, they acquire many skills, ranging from the best ways to study geographic relationships to the most effective means of presenting their investigations. Students become project planners, collaborators, producers, and decision makers. Experience in PBL-GIS classrooms shows that students are motivated to work to solve real world problems and appreciate the autonomy they have in PBL-GIS activities. They enjoy working cooperatively with fellow students and learning together.

Model One: A Simple Approach

In a simple, relatively unstructured approach, PBL-GIS follows four stages:

1. Stage One: What do we know? To start, present a topic related to part of your curriculum. See the feature "Selecting a Topic" for hints on choosing an appropriate subject. Let students discuss the subject in broad and general terms in order to clarify key terms and concepts, and to begin to understand it. This is an opportunity for students to remember what they already know about the topic and to organize their thoughts and understandings.

2. Stage Two. What do we need to know? After initial investigation and discussion, help students reconceptualize the topic as a problem or inquiry. Students should define one or more key problems as questions related to the topic and formulate some initial hypothesis and analyses. Ask students to consider the information they will need to investigate the topic. What secondary data is available? What primary data will they need to collect? What kinds of analyses will be required to solve the various problems under discussion? How will GIS help in solving the problem?

3. Stage Three. What are we going to do? Next, students, either alone or in small groups, decide specifically what problem they wish to investigate, the resources and methods they will use to complete their investigation, and the products they will produce as evidence of their problem solving (maps, reports, oral presentations, Powerpoint slide show and so on). As students select specific problems or questions to study make sure that they follow five criteria. The problem or inquiry question must be 1) meaningful; 2) important and core to a specific subject area; 3) complex, that is, having no simple, obvious answer; 4) relevant to the topic under study in class; and 5) original (Windschitl 1999).

In PBL-GIS students typically produce GIS-based maps. These maps are analyzed and interpreted. Inferences are made from the maps to formulate generalizations and to make decisions, solve problems, and form judgments about the question, issue or problem under study. Students should explain (orally and in writing) their findings and how they reached their conclusions. It is important that students have clear plans and opportunities to articulate the concepts, skills, and methods they have learned. Using GIS is one thing; analyzing and reporting the results is where learning takes place.

4. Stage Four: What have we learned? In this last stage, students complete their investigations and prepare and present their findings. This is when they work with GIS and other tools of analysis. Students require help conducting their research and monitoring their learning. In PBL-GIS students are balancing three tasks at once: 1) they are learning about a topic and its associated problems, 2)

they are learning how to use GIS to investigate those problems, and 3) they are making decisions regarding when and how to use GIS to conduct their inquiry in order to solve a problem. When they have completed the research, they will need assistance in structuring their results and summary presentations.

These four stages flow from one to the next seamlessly. You may find students have to revisit each stage's key questions more than once as they work through a problem.

This graphic summarizes the stages and suggests ways teachers can help students and student roles and responsibilities.

Stage	Role of Teacher	Role of Student
Stage One. Clarify Topic. What do we know?	Facilitator Guide Co-learner with students	Problem solver Co-learners (discussing and sharing ideas)
Stage Two. Identify Problem(s). What do we need to know?	Guide (to define problems) Resource (to suggest data sources) Planning Assistant (working with students) Manager (to assist in organizing student groups and work)	Planner Decision Maker Problem solver
Stage Three. Plan Inquiry What are we going to do?	Resource (suggesting materials) Model (GIS; Problem solving; Research skills) Guide (Check student work plans; Suggest strategies) Facilitator (Coordinate resource use and student interaction; Monitor progress; Anticipate resource needs)	Producer Problem solver Planner Teacher (Helping other students with GIS and analysis)
Stage Four: What have we learned? Investigate and Report	Model (GIS; Problem solving; Research skills) Guide (Manage presentations) Facilitator (Check student findings)	Producer Teacher (sharing findings and teaching classmates; Helping other students with technology)

Model Two: A Detailed Approach

This model outlines a more highly structured version of PBL-GIS. The steps mirror Model One but this approach provides students with more organization and less autonomy. It gives you the opportunity to select problems and issues well-matched to the GIS data and base maps you have available.

1. *Select a problem.* See the feature "How to Select a Problem" for guidelines on choosing a good topic. Match the problem to national, state, and school district standards that you are required to teach. You may wish to combine standards and curriculum objectives from more than one subject area (for example, geography, science, and language arts or social studies, science, and mathematics) to select a worthwhile, relevant, and useful problem that offers students many opportunities to learn

significant content and skills. Make sure that you have access to adequate resources to support an in-depth investigation of the problem you select.

2. *Develop a scenario.* Place the problem in context by developing a rationale, event, or scenario to present to students to introduce and stimulate their investigation. Provide background on the problem in the scenario and a statement of why it is important. Justify the investigation for students and link it to the real world and their personal interests and concerns. Make it as real world and exciting as you can. Specify the questions that students will define and answer in the course of their investigation. Let students know if they will work alone or in groups, and how the groups will be organized.

3. *Determine unit products and outcomes.* What will students produce in the course of their investigation and by what criteria will these products be evaluated? What tasks do you wish them to complete? Decide if students will produce group products, individual results, or a combination of group and individual assignments. In addition to using GIS, you may require students to develop brochures, write memoranda, prepare proposals, illustrate research reports, construct exhibits, present their work to community members or build web sites that incorporate their GIS-based findings. Be clear about how you will assess the assignments and student performance expectations in general. Again, check your curriculum guidelines and standards to make sure you are giving students opportunities to learn challenging content matter and skills. Consider available resources, access to technology, assessment criteria and formats when considering outcomes and assessment. Be clear about your expectations but firm in placing students at the center of the problem solution.

4. *Develop a Work Plan.* Outline how students will proceed with the investigation. What strategies will students use to proceed with the research? Use a calendar to schedule the progression of assignments and to organize the flow of the activities. Make sure students have adequate time to gain the skill and fluency they need to address the problem. Guide, check, and monitor student progress through journals or other forms of self-reflection. Develop strategies to manage student access to resources and research tools they use in the investigation, including GIS. Model how to use GIS and how to think geographically but give students a chance to teach each other and to explore the data and software on their own. Support students when you see they are frustrated but do not do the work for them.

5. *Communicate results and share and analyze products.* Debrief and reflect with students when they have completed their research. What are the solutions to the problem? Are there different viewpoints on the issues they researched? What are they? What did they learn in terms of subject matter and skills? How did GIS help them in their research? How do students assess their own performance in this activity? What learning strategies and responsibilities were most useful to them?

You may wish to organize this final stage of PBL-GIS as a 'culminating event' and invite parents and community members to hear student research findings. Or you may wish to share student products with others. The last stage is very important; it cements student learning by making students actively aware of their accomplishments.

Assessment in PBL-GIS

In PBL-GIS, GIS-based authentic tasks and problem based inquiry require performance based assessment. Student achievement and content and skill development are assessed by evaluating the products and performances they complete. It is important that clear and specific criteria are developed to lead students through a PBL-GIS activity. Scoring guides or rubrics that establish your expectations for performance are useful for students and send a clear message of your standards. Be sure the scoring guide includes all the outcomes that you value, including developing a reasoned and

sensible solution to the problem under investigation, communication skills, and content knowledge. It should include measures of how well students have learned about the problem as well as the use of GIS.

In addition to final product evaluation, you may also wish to develop a sequence of assessment tools to manage a PBL-GIS investigation and to ensure students stay attentive and motivated. A daily grade based on observations, student group-teacher conferences, or journal records helps students to 'stay the course.'

Selecting a Topic

Selecting a good topic is crucial to the success of PBL-GIS. You want to use resources that you have but you also need to keep these criteria in mind as you refine your problem.

1. Scale. A good topic ranges from local to global concerns. For example, global climate change affects students' own communities as well as the world. Students can study issues at a range of scales. A topic that allows students to zoom in and out looking at data at a range of scales works well for PBL-GIS.

2. Relevancy. Good topics touch students' lives. Community based research and service learning are motivating and compelling to most young people. They allow students to develop strong citizenship skills by working together to solve a problem. A topic that encourages students to generate their own problems and to take action is good.

3. Continuity. An effective topic links the present to the past and gives students opportunities to consider the future. Looking at change over time is a powerful tool of analysis.

4. Ethics. A topic that features moral and ethical dimensions will give students opportunities to learn to use reason to make emotional decisions.

5. Interdisciplinary. A topic that allows the integration of several disciplines and skills is worth spending class time on. Make sure there are opportunities for a variety of tasks and that students have some choices. The focus should not be too narrow. Geography and environmental science topics lend themselves to cross-disciplinary exploration.

6. Complexity. A problem should be complex and open ended enough to interest and motivate students but not too unwieldy and challenging.

7. Rigor. Select a topic which is rigorous, challenging, and interesting to students based on its complexity and issues, not just on the amount of information it encompasses.

8. Authenticity. Pick a topic that is rooted in the real world and which is significant because of its implications.

Adapted from Glasgow 1997.

Why PBL-GIS?

PBL-GIS is an effective way to organize classroom learning for four reasons: it enhances student learning, it motivates students, it prepares students to make smooth school-to-work transitions, and it makes teaching with GIS manageable.

1. Learning. There is broad consensus among teachers today about what constitutes good learning. Teachers agree that learning

- is an active process in which students connect new ideas to old understandings,
- is improved by student-to-student dialogue and cooperative learning,
- is most motivating and interesting to students when placed in real world contexts,
- should be student-centered, that is, students should make decisions to control their own learning,
- requires students to reflect on their experiences and to be able to explain to others what they have learned,

- is life-long, that is, it is vital that students learn how to learn in order to continue learning throughout their lives (Ryan 1997, Windschitl 1999).

PBL-GIS is the theoretical framework which best captures these ideas.

When learning with GIS students are called upon to use three types of knowledge. First, they must know content. This type of knowledge is called declarative knowledge. Declarative knowledge is 'knowledge that...' or 'knowledge about...'. Second, students must know how to use GIS software, for example, how to display different layers of data and how to join databases. Such skills are termed procedural knowledge and represent 'knowledge how...'. Third, and, most importantly, students must know when and why to use certain procedures (queries, projections, comparisons, and so on) to answer particular questions. This type of knowledge is called conditional knowledge, that is, knowing under what conditions, when, and why to use a procedure. (West, Farmer and Wolf 1991). PBL-GIS offers students opportunities to master all three types of knowledge at once, in an authentic, real world context.

Three Types of Knowledge Students Use with GIS

Type	GIS Examples
Declarative: Knowledge <i>that</i> or <i>about</i>	Content-based facts, concepts, and generalizations
Procedural: Knowledge <i>how</i>	How to display different layers of data; how to join databases
Condition: Knowledge <i>when</i> and <i>why</i>	When and why to use certain procedures (queries, projections, comparisons, and so on)

2. Motivation. PBL-GIS is fun for students and teachers. Each case study in this book affirms that students enjoy working with GIS to solve real world problems. Such work is exciting, engaging, and active, not boring, static, and passive.

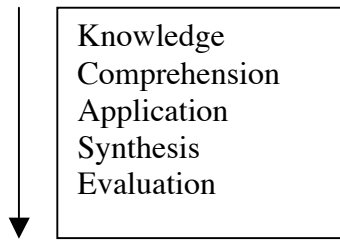
PBL-GIS is motivating for two other reasons relating to curriculum structuring strategies. and assessment.

Curriculum Structuring Strategies. In the past, conventional teaching wisdom viewed learning as a hierarchical activity as developed in Bloom's Taxonomy of Learning. It was believed that students had to learn basic knowledge and skills before going on to more sophisticated and advanced learning such as problem solving and decision making. Curriculum was developed and lessons structured to begin learning at the lowest levels of the learning hierarchy. Subsequent lessons moved up the taxonomy until students were 'ready' for higher level activities such as evaluation and synthesis. As a result, students were subjected to dull boring tasks emphasizing basic skills and facts as a 'necessary' precursor to more challenging and engaging tasks. Too often, they became bored and lost interest in a subject during this initial phase of work.

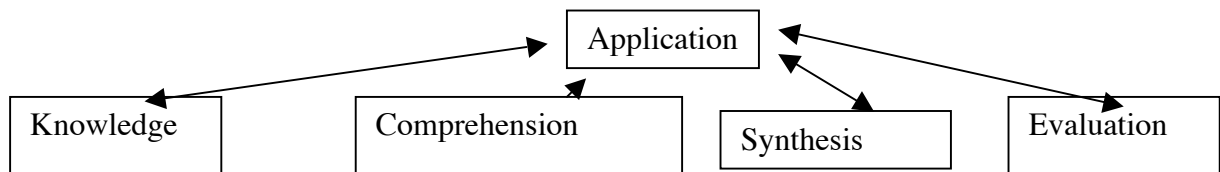
Today, teachers using PBL-GIS understand that students can learn basic facts and skills in context and as part of the process of problem solving, on a 'need to know' basis. In PBL-GIS knowledge and skills arise from work on a problem. Students find this a more natural, relaxed, and comfortable way to learn (Ross 1997).

Curriculum Structuring Strategies

Traditional Model



PBL-GIS Model



Assessment. In PBL-GIS students have a sense of ownership in learning because they are making key decisions about the resources to use, about how to go about solving problems, and about the most effective ways to present their findings. Students and teachers have a clear understanding of final products and outcomes and clear assessment criteria. Right up front, students know what they have to do and how well they have to do it. If the product is known and clear criteria are outlined for the product, students escape test anxiety. This is highly motivating to students.

3. School-to-Work Transitions. PBL-GIS prepares students for the workplace of the 21st century. The skills valued by employers in both the public and private sector are all employed in PBL-GIS. They include

- the ability to work in small groups,
- the ability to apply problem solving skills and strategies to real world issues,
- the ability to communicate effectively orally and graphically.

PBL-GIS connects students with the real world and teaches them to use a marketable skill to solve community based or real world problems. It also teaches them a valuable perspective, how to think geographically.

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