Rendezvous with a Comet Teacher's Guide

The time is far in the future....

Astronauts have traveled to the moons and planets of the solar system....

They are now ready to begin flights to nearby stars…

You are a member of a special team whose task it is to determine what sort of space aliens might be found on far away worlds…

While no life has been discovered within the solar system outside of planet Earth, that might not be the case with other worlds orbiting distant stars....

To get an idea of what other advanced life forms might be like should the astronauts find them (or if they should come to visit us on Earth first!), your team has been asked to study the moons and planets of our solar system. You will determine what sort of life forms could be living on these worlds.

What are the conditions on other worlds, and what might life forms look like that have naturally adapted to these conditions? Are these places hot or cold, light or dark, wet or dry, oxygen rich or oxygen poor, high pressure or low pressure, high gravity or low gravity, thick or thin atmosphere, lightning or no lightning, winds or no winds, water or no water, etc.?

You and your research team have been invited to design a space alien that is best adapted to life on one of the solar system's planets or moons with atmospheres. Those bodies are Venus, Mars, Jupiter, Saturn, Uranus, and Neptune, as well as Saturn's moon Titan. Mercury has no atmosphere, and Pluto has not been considered a planet by the astronomers of the International Astronomical Union since August 25, 2006.

- Design a Space Alien

PROBLEM-BASED LEARNING – Problem-Based Learning (PBL) is a form of curriculum that deals with both the content and processes of what is to be learned. It is an instructional approach that helps students to become active problem solvers using a real-world problem. The PBL approach can do amazing things for students. Properly implemented, a PBL activity can build multidisciplinary knowledge, integrate knowledge from a variety of disciplines, assist in values clarification, help students see the utility of many disciplines, help students apply what they know about subject matter to real-life situations.

The PBL approach places students in active roles as problem solvers. The approach confronts students with a complex problem that does not necessarily have a single best answer. The problem-solving process will be messy and complex, just like in the real world. A solution of the problem will require students to inquire into the stated problem, gather information, and reflect upon the findings. The solution will always be tentative and changing as more information is obtained and internalized. Students working in small groups will frequently find that they are

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required to state and defend their conclusions on the basis of evidence and argumentation. This provides students will both a challenge and motivation.

Good PBL problems will always require students to learn both broadly and in depth before they will be able to provide meaningful, practical solutions to the real-world problem provided. A good PBL statement will appeal to the human desire for a resolution, and thereby sets up the need for context of learning. The problem will necessarily be based on desired outcomes, learner characteristics, compelling situations, and suitable resources. Several examples of PBLs follow:

- How can we best defend the Earth from an asteroid of comet impact?
- Is it wise to locate a theme park in an environmentally sensitive area?
- Should a nuclear waste dump be built in someone's back yard?
- What is the value of conducting the search for extraterrestrial intelligence?
- How should we modify society to best conserve limited energy resources?
- Should nuclear energy replace fossil fuels, or should we use an alternative?

In preparing a PBL activity, the teacher anticipates learners' needs, and makes resources available through such things as laboratory materials, books, and WebQuests.

PBL BENEFITS – Solving problems such as those given above, students learn to become critical thinkers and active problem solvers. By being placed in active roles as critical problem solvers, they come away from a PBL experience understanding personal and societal values, and become much more capable of solving complex, real-world problems. In learning to find solutions for such problems they develop and hone important job-related skills such as the following:

- **Problem Solving** – students develop authentic problem-solving abilities associated with real-world phenomena. In so doing, they investigate information, examine issues, formulate and propose solutions supported by reason and evidence. This includes clarifying individual and societal values.
- **Communicating** – students learn to gather, read, interpret, and share information, ideas, and conclusions. Both written and oral exposition skills are practiced and improved.
- **Using Technology** – students come to know how to use important equipment such as sensors, computers, and networks to gather information, process data, draw conclusions, and communicate results.
- **Working on Teams** – students learn the rules of appropriate social and to contribute as productive members of a group.
- **Making Connections** – students identify important connections between ideas when addressing various issues that involve a number of learning areas; they develop and integrate multi-disciplinary knowledge at a greater depth than would normally be encountered during conventional teaching. The process helps students to understand the value and limitations of science. It helps students see the utility of science and come to realize its role in solving authentic problems.

PBL METHODOLOGY – The PBL methodology calls for the design of an authentic, real-world problem with highly compelling to the students. The problem statement is typically ill structured and based on desired outcomes, and learner characteristics. It is imperative that the problem be one in which there is no "right" solution, and which students cannot immediately forecast the outcome. The PBL problem must require the use of inquiry, information, and reflection. It involves students making value judgments. It demands that students make and defend their conclusions on the basis of evidence and argumentation. The problem is one that

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provides both a challenge and motivation; it must appeal to the human desire for resolution, and sets up a need and context for learning.

In the PBL classroom, students change from passive receptacles of information to active investigators. The PBL process stresses learning over teaching. The problems that students encounter are messy, real-world problems with no clear answers. As a result, PBL problems tend to be both engaging and motivational. Students learn what it means to be a scientist by working in context. The PBL process demands the use of higher-level critical thinking and problem-solving skills. In the end, PBL helps students learn how to think and not what to think.

COOPERATIVE LEARNING A cooperative learning environment is essential to the success of any PBL. The cooperative learning environment must have the following components if the work isn't going to degrade into non-cooperative group work.

- shared learning goals – desired future state in which the students demonstrate, as a group and individually, a mastery of the subject studied
- goal structure – specifies the ways in which students will interact with each other and the teacher during the instructional session

The teacher must set up and use strategies that ensure cooperative group work. This can best be done by ensuring that the "PIGS FACE" components of Johnson, Johnson, & Holobek "Circles of Learning" (1998) is fully incorporated into any PBL. See this excellent short reference work for details.

P – Positive Interdependence. Students must understand that they have two responsibilities in cooperative groups: (1) they must learn the material required to solve the problem, and (2) they must ensure that all members of their group learn the material. Each student should see his or her work as benefiting the group effort; each student's effort must be seen as essential; each student make unique contributions. Interdependence occurs when students cannot succeed unless their group members also succeed. Structuring interdependence requires a common goal, joint rewards, equitably distributed resources, and complimentary roles

I – Individual Accountability. Teacher must assess how much effort each member is contributing to the group's work. Teacher must communicate concerns to groups and individual students as necessary. Teacher should help groups avoid redundant efforts by individual team members. Teacher must ensure that every member is responsible for the final outcome. This is most commonly done through good assessment procedures that have clear performance expectations and public criteria. Assessments should be provided out the outset and generally should take the form of rubrics.

G – Group Processing. At end of learning process, or even periodically throughout the process, students should be helped to reflect on what member actions are (were) helpful and unhelpful. Students then make decisions about which actions to continue, change, or delete. Such processing allows groups to: focus on maintaining good working relationships, learn cooperative skills, provide feedback on member participation, think at a metacognitive level as well as cognitive level, and celebrate success of the group.

S – Social Skills. Students must get to know and trust one another. This will allow students to communicate accurately and unambiguously, accept and support each other, and resolve conflicts constructively. It should be pointed out again for the teacher that many students do not come to the classroom with appropriate social skills for working in cooperative groups.

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This is how cooperative group work degrades to the point where it becomes the work of only a few or even one.

FACE – Face-to-face interaction. Interaction occurs as a result of the positive interdependence. To maximize opportunity for success, keep groups small (2 - 6 students), keep groups heterogeneous (a good mix of ability levels), assist students with guidelines for interaction that include aspects dealing with acceptance, support, trust, respect, exchange of information, and the role of personal motivation.

THE ROLE OF THE TEACHER IN PBL – Problem-Based Learning empowers teachers to become active facilitators of student learning and active designers of curriculum. As a PBL facilitator, the teacher role changes from implementing an externally imposed curriculum (e.g., textbook), to being an active decision maker in the curriculum planning process. Under the PBL environment, the teacher changes roles from that of disseminator of information to a facilitator of learning. The teacher will model appropriate problem-solving strategies, coach students in their work, and then fade from the scene as purveyor of information to become a facilitator of learning as the students become engaged and self-directed. The teacher will ask about student thinking, ask probing questions, challenge students to explain and justify, monitor student learning, adjust challenges as needed, and manage group dynamics. The teacher will set clear performance objectives, and explain how performance assessments will be conducted. Once the problem is set up, the teacher anticipates learner needs, makes resources available, and facilitates student definition of the problem through cycles of know/net to know/how to find out. Teachers model, coach, and fade in supporting the student learning process. As a facilitator of learning, the teacher challenges students, asks questions, stimulates student thinking, and provides learning resources for problem solving and self-directed study. Teachers help students become responsible for their own learning. PBL-oriented teaching ensures that important content objectives of the curriculum, standards, and benchmarks are met, including important, real-world problems. The process reaffirms the importance of certain learning objectives, and results in the elimination of others because they lack relevance or importance.

PBL CLIMATE SETTING – PBL is conducted under what is for some students a radically different atmosphere, and PBL climate setting needs to be part of every classroom teacher's management plan. In climate setting, teachers help students understand that the roles of teachers and students change. Teachers are no longer seen as purveyors of information; rather, they are seen as facilitators of student learning. Students are no longer seen as empty receptacles to be filled by teachers; rather, they are seen as active inquirers who must take responsibility for their own learning. Students must have an understanding of this shifting climate, and this difference should be pointed out on a daily basis, especially with students unfamiliar with the PBL process. This might seem overly repetitive, but it is extremely important for a successful PBL experience.

Climate setting includes two critical components – the role of the teacher and the role of the student. Students need to understand what the authentic role of the teacher is – preparing situations under which students can learn. They must understand that learning is the responsibility of the students. The PBL teacher will set up a problem, anticipate student needs and provide access to needed resources. The teacher will play the role of the mentor, and students will work cooperatively to solve the problem presented. Students must focus on the task, and follow social and intellectual rule of conduct.

Teachers should make clear to students that they might ask questions even if they know the answer; that they might ask "why?" two or three times in a row, that they will ask students to explain and justify their conclusions on the basis of evidence. Teachers must point out that questioning an idea does not mean that it is wrong. Students need to understand that their role is

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to speak up, ask questions, confront apparent fallacies, and ask questions when they don't understand. They must see the educational process as the construction of knowledge in which ideas are clearly stated and clearly evaluated. They need to know that no idea is "stupid", and that the only poor question is the question that is not asked. Students must assume responsibility for constructing meaning from facts that they have gathered as part of the PBL process.

Because PBL is very interactive in nature and depends strongly on cooperative group work, teachers must clearly state expectations for student interactions. They must not assume that students have a good understanding of what it means to work cooperatively. Teachers must assist students in gaining an understanding of the social aspects of cooperative group work. They must assist students clarify tasks and procedures, and how students can work together equitably and fairly to attain a common goal. The teacher must help students understand that the solution of the PBL problem belongs to them, not the teacher. In the end, teacher must help students understand that they are responsible for their own learning.

Students will sometimes resist inquiry-oriented instruction. It is always easier to sit passively in class than have to think. Parents and school administrators should be informed about the educational approach being used. It is better to inform parents and school administrators in advance of starting a PBL process. For pointers about this process, see "Minimizing resistance to inquiry-oriented instruction: The role of climate setting" appearing in the *Journal of Physics Teacher Education Online* (http://www.phy.ilstu.edu/jpteo/issues/dec2005.html).

SETTING RULES OF SOCIAL ENGAGEMENT – Neither PBL nor cooperative learning approaches assume that students come into the classroom with appropriate social behavior skills. That students do not possess these skills is clear when supposed cooperative group work rapidly decays into one person doing all the work while others take partial credit for the work. Improperly instituted, even cooperative learning will rapid decay into the more traditional group learning. In an effort to prevent this from happening, it is important that the PBL teacher teach social skills relating to whole-group and small group interactions.

Class Participation Rules

1. Every student will contribute to the discussion.
2. Every student will be non-judgmental of other student's opinions.
3. Every student will have the opportunity to express his or her ideas without their ideas being attacked.
4. Every student will ask questions when an idea or fact is presented that they do not understand.

Group Participation Rules

1. Each member of the group will contribute to the project.
2. Each member will avoid the use of put-down language.
3. Each member will get to know and learn to trust others.
4. Each member communicates accurately and unambiguously.
5. Each member accepts and supports other students.
6. Each member will resolve conflicts constructively.
7. Each member of the group will talk to or interact only with his/her group.
8. Each group member will be present and ready to work.
9. Each group member will do the research or work assigned to him/her.

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10. Each group member will be present for group presentations or their grade will be lowered. If the absent group member does not wish to have their grade lowered, (s)he can come in on their own time and deliver an oral presentation by him/herself.

PBL MENTORING – The PBL teacher will mentor students through the PBL process. As mentor, the teacher must provide clear models, set expectations, establish structures, give appropriate support, and direct students to useful resources to help solve the PBL problem. The PBL approach will in all likelihood be new to students, most of whom have come to know the teacher as "sage on a stage" rather than as a "guide on the side." The students will need assistance with setting up structures to identify and complete group and individual tasks. At the same time, the teacher must avoid serving as a source of information.

The mode of interaction between teacher and students should focus on teacher questions. The mentor should help students understand whether or not they know something by asking appropriate questions.

During the mentoring process the teacher must avoid providing answers, solving the problem for the students, and providing positive reinforcement that directs students toward certain solutions. Teachers should use non-judgmental responses when students make contributions that direct a group's work in a certain directions. Mentor responses such as "that's interesting," "fascinating," or "insightful" are appropriate at these times. Nonetheless, positive reinforcement is appropriate when students are contributing in significant ways to the problem-solving process (i.e., talking about how best to achieve a particular goal).

Teachers as mentors need to understand that the PBL process takes time, and that some of the most productive time in the classroom is when there is no central focus of action. Rather, much work is accomplished by students when they have opportunity to speak, listen to others, and think. A good mentor will allow students to be the center of discussion. They will facilitate student efforts, rather than direct students to do things that they feel should take place. They will provide for times during which students might develop genuine insights. Allow students to learn from other students. If they allow students the opportunity to work as teachers, mentors will be surprised at how much students know, and how well they can teach their peers.

While as mentors teachers should avoid taking charge in the classroom during cooperative group work, they should feel free to contribute to modeling and helping students take charge of their own learning. The teacher as mentor should put into place a mechanism for regularly allowing students to talk about what works and what doesn't work. The teacher needs to promote and support cooperative learning so that it doesn't evolve into group learning where one student does all the work, and the others contribute little to nothing.

PBL ASSSESSMENT – A PBL lesson requires that students create a "product" or "performance" that is aligned with the original problem statement and which is the basis for assessment. Because PBL involves students at a variety of levels, it is reasonable that self-assessment, peer assessment, and teacher assessment takes place during and at the end of the process. Three types of assessments will be used in this project:

- Teacher assessment of the content and style of the written reports
- Peer assessment of students' oral reports
- Peer assessment of contributions to team efforts

There are three detailed rubrics that can be used by teachers for scoring each team's written and oral reports, as well as for a peer review of cooperative group efforts. These rubrics parallel the report guidelines in the WebQuest, and can be found hyperlinked on the teacher's web site.

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PBL SITES – A number of good PBL sites are available on the Web that might provide additional assistance in getting to understand the process. The following are recommended:

WebQuest:

"A WebQuest is an inquiry-oriented activity in which some or all of the information that learners interact with comes from resources on the Internet.... After completing a longer term WebQuest, a learner would have analyzed a body of knowledge deeply, transformed it in some way, and demonstrated an understanding of the material by creating something to which others can respond." Bernie Dodge, San Diego State University. The WebQuest Page at SDSU

County Board Dilemma: A Low-level Nuclear Waste Dump in Your Community? A WebQuest

County Board Dilemma: A Nuclear Power Plant in Your County? A WebQuest

Additional PBL activities on the Internet

University of Delaware PBL Site

IMSA's PBL Web site (see especially *Cosmic Collisions*)

SCORING RUBRICS – Near the end of this section of the Teacher's Guide are detailed rubrics that can be used for scoring each teams' work. They parallel the report guidelines in the WebQuest. Expert essays should reflect the processes and procedures of critical thinking; oral presentations should reflect critical thinking dispositions.

Expert Essay Scoring Rubric

Oral Presentation Scoring Rubric

Peer Participation Scoring Rubric

CONNECTION BETWEEN PBL1 AND PBL2 – The writers of this teacher's guide have prepared PBL1 as an introduction to problem-based learning. If students have experience with doing performance-based learning activities, then PBL1 can be skipped. If students do not have experience with problem-based learning, then PBL1 should not be skipped. Teachers should, however, feel free to move ahead quickly with PBL1 as PBL2 can often take five weeks or more of preparation time. PBL1 is not designed to meet science content teaching standards in the way that PBL2 actually does.

MANAGING *RENDEZVOUS WITH A COMET* – This *Rendezvous with a Comet Teacher's Guide* was first piloted during the 2005-2006 school year. Six experienced 5th and 6th grade teachers who had previously taken their students to their Challenger Learning Centers for missions were chosen as reviewers for this project. They provided the following advice as part of a debriefing session following the conclusions of their missions:

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- There is one key to managing *Rendezvous with a Comet* – prepare, prepare, prepare. Preparation must be done 6 to 12 weeks in advance because it will take considerable time to assemble the required materials.
- First time teachers will struggle with this project, unless they are very organized.
- It will be difficult to manage the process the very first time, but subsequent missions will be much easier due to the prior planning.
- Some teachers will find it easier to manage and organize tasks by first printing out all needed Teacher Guide materials.
- Set aside folders or boxes for each mission team, as well as a box including whole group activities. Team activities will take more time to plan and implement than will whole group activities.
- While preparing for the missions is difficult and time consuming, it is well worth it.
- Organize a timeline for preparatory work, and stick with it. The work might otherwise seem overwhelming.
- The teacher should be familiar with each of the activities included in the teacher's guide, and should try them before using them with students the first time.
- The teacher should work through the *Design a Space Alien* PBL.
- The importance of climate setting cannot be overestimated. Do it from the beginning, and repeat regularly. Tell the kids that this might be difficult, but that they will benefit.
- The more organized and prepared the teacher is, the better the outcome of the project.
- Feel free to include you own materials and assessment, supplementing your lessons in as many ways as you feel best.
- Proof the WebQuests for hyperlink accessibility. Some schools have "firewalls" in place that might keep students from accessing important Internet sites. Work with your system administrator in advance of having students begin work with either of the PBLs.

PREPARING TO TEACH THIS UNIT – Follow-up interviews with six 5^{th} – 6^{th} grade pilot project participants suggest that teachers should be aware first and foremost of the fact that preparation time for teaching this unit is large and critical. Teachers probably will want to conduct up to about 10 whole-group activities and follow this with four or more small-group activities for each of the student teams. It probably would be best if teachers would prepare in advance containers holding materials for each of the activities so as to avoid confusion. Secondly, teachers should be familiar with the content and processes of the associated problem-based learning activities before beginning work with students.

This teacher's guide should be thought of as a starting point. Teachers should feel free to pick and choose from among the various activities provided, and to pick and choose as well as augment the curriculum with their own instructional and assessment materials. For instance, a teacher might feel that a post-mission press conference would be anticlimactic given the intense nature of the preparatory and mission experiences. Teachers should feel free to create their own rubrics and assessment activities or modify those found herein. Don't forget to include self-assessment and daily participation if these are important to you as well.

If time for the mission preparation is a problem, consider working with other teachers in a classroom field trip activity.

It is important to have access to computers to help students with the various projects. Build in extra time for problems with technology, as often is the case. Video projector would be very helpful in helping students move through the curriculum.

BASIC STEPS FOR IMPLEMENTING CURRICULUM – There is no magic formula for implementing the curriculum presented in this teacher's guide. Nonetheless, the following basic steps might prove to be helpful:

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1. Attend a teacher preparation workshop based on this curriculum that is offered at your local Challenger Learning Center.
2. Observe or participate in the associated CLC mission during or following your local workshop.
3. Review in detail the student and teacher web pages associated with this mission; further practice navigating various web pages so you can be familiar with the protocol.
4. Examine PBL1 and see if it can fit more meaningfully somewhere in the curriculum earlier in the year; it need not immediately precede PBL2 in the curriculum.
5. Rank the whole-group and small-group activities by priority. Chances are you'll not be able to do all activities, and only the most important or "doable" should be chosen. Each year as your experience grows, you can revise and add to this listing. Supplement if you can't do the indicated activities for any reason.
6. If necessary, develop a matrix that aligns chosen activities with state and/or national teaching standards.
7. Review available assessment activities; update or develop rubrics as appropriate.
8. Review how you will introduce students to PBL1 and PBL2; this includes examining availability of classroom computers and/or a single computer with video projection capability.
9. If necessary, reserve regular computer lab space and review needs with your school computer technologist.
10. Arrange with school librarian any needed textual resources.
11. Make copies of any handouts that might be needed.
12. Gather resources for whole- and small-group activities; experienced teachers find that it is very helpful to prepare small boxes with all required materials and handouts.
13. Introduce PBL1 using a computer with video projector. Include the following steps:
    a. Introduce problem
    b. Review scoring rubrics and give copies
    c. Conduct climate setting
    d. Address problem of social engagement
    e. Divide class into heterogeneous teams of 3
    f. Make spreadsheet to encapsulate team information
    g. Assign projects to teams
    h. Each team establishes member roles
    i. Start with "know/need to know" sheet
    j. Assignment – homework/computer lab/written report
    k. Stress need for citing sources of information
14. In the beginning and regularly thereafter conduct classroom climate setting.
15. Periodically restate mission goal, and review problem and rules.
16. Review written and oral report rubrics as appropriate.
17. Allow time as necessary for group report development.
18. Students submit written and present oral reports.
19. Conduct peer assessment.
20. Introduce PBL2 using computer and video projector.
21. Go over questions using "know/need to know" form.
22. Give work assignments and answer general questions.
23. Work on and turn in job applications; teacher assigns students to teams.
24. Begin work on mission patch.
25. Conduct other whole-group activities.
26. Conduct small-group activities.

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27. Review mission procedures for visit to your local CLC.
28. "Fly" CLC mission
29. Post-mission activities and follow up.

TEACHER COMMENTS

In regard to mission prep, here's what works for me: I've found that it works best when I fully prepare the separate team stations in advance and then let the students work semi-independently during class time... I supervise the groups, but I ask them to see if they can solve their problems on their own if possible. The actual mission requires them to think on their feet so it's good practice for them to take ownership of their role early on... I admit that this method does take quite a bit of prep time, but it pays off if you are able to have your hands-on materials and some additional written material there on a clipboard so they can work with both aspects of their job with a minimum of input from the teacher.

Sue Law
Jack Hille Elementary School
Oak Forest, Illinois

I've always started out preparing for Challenger with group activities (The Mission Prep book and the Comet Book). I tell students where each of the activities fit in. For example, I tell them that acids and bases are associated with Life Support. Then, students can make an educated selection for the type of job to which they would like to apply. I also do other activities like reading graduated cylinders, volume, pulse, etc., with the entire class. We also do some extensions like chromatography of black markers and even Kool-Aid. I probably do this for about a month or so, 4 days a week.

After each team is selected, I have organized individual stations for each job. For example, for REM I have a "glove box" with large gloves. Students must weigh and do volume on each item. We work on both team building and skills for the job they have been selected for. After two weeks of individualizing, we're ready for launch!!!!

Tina Roznawski
Abraham Lincoln Elementary School
Hammond, Indiana

PILOT PROJECT TEACHER COMMENTS – The following comments were recorded during the post-mission debriefing interviews:

The field trip is the coolest thing in the world for the kids.

Socially struggling kids had to improve or be left behind; the positive social aspects to this project are clear.

I really liked the approach that resulted in integration of a wide array of subject matter and the utilization of instructional technology; PPT congressional hearing presentations on basis of teams were great; great way to focus attention on importance of their team jobs.

Yes, this is an exciting thing for fifth graders. They take this so seriously. They see it as real.

The students really preferred this active approach to listening to me and the other teachers lecture; the kids were well behaved, and climate setting was done and found helpful.

I think that you need to tell new teachers, "You have to trust it; go through it sequentially; it works. It will take about 3 years to come up to speed."

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I think this is an excellent opportunity for the kids; it makes them think; they are so excited about it. I love the program. It's a wonderful hands-on program. From low SES school, it's wonderful because activities really help build and tie kids into the real world.

It is an excellent program; I think kids do remember it and the science and the cooperation and what it takes.

This is one activity that my kids remember each year.

Having done PBL2, kids are much more independent during the CLC mission – they have learned to rely upon themselves rather than on the teacher. The CLC mission evaluation shows it.

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- Laurie Kaufman, 5th grade, Ridgeview Elementary School, Colfax, Illinois
- Diane Nealey, 5th grade, Ridgeview Elementary School, Colfax, Illinois
- Tina M. Roznawski, 5th grade, Abraham Lincoln Elementary School, Hammond, Indiana
- Candy Wilson, 6th grade, Boone Grove Middle School, Boone Grove, Indiana
- Lynda Wingler, 5th grade, Prairie Elementary School, Urbana, Illinois

CLOSING COMMENTS – The teachers who piloted this project have informed us that things can be confusing at first if the teacher and students have no prior experience with problem-based learning. Things go much better the second time around. Teachers remark that PBL results in very significant improvements in student comprehension and retention. Motivation is heightened with a concomitant change in student performance. As one teacher remarked, "I'll never teach without using PBLs in the future." Another remarks, "This was the best ever. These kids really got it together, really bought into it. They really thought that the process was great and want to use it again." The PBL approach used in this teacher's guide is novel for many teachers; teachers, too, can expect to be "stretched" as they learn to use new and more effective classroom techniques. Don't be surprised if the road is a bit "bumpy" the first year; things undoubtedly will improve next year as you learn to deal with this student-centered form of classroom instruction.

REFERENCES:

Johnson, D., Johnson, R. & Holubec, E. (1988). *Circles of Learning: Cooperation in the Classroom.* Edina, MN: Interaction Book Company.

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