Baby Steps to PBL Success: Lesson from Teachers Implementing Project Based Learning

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Jean Lee, University of Indianapolis

How do I transition to project-based learning to engage my students in rigorous, authentic, and relevant challenges?
### Problem-Based Learning (PrBL) vs Project Based Learning (PBL)

<table>
<thead>
<tr>
<th>Problem-Based Learning</th>
<th>Project-Based Learning</th>
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<tbody>
<tr>
<td>Standards-based</td>
<td>Open-ended Driving Question</td>
</tr>
<tr>
<td>Solutions should allow for multiple strategies</td>
<td>Focus on product AND process</td>
</tr>
<tr>
<td>Specific task or problem</td>
<td>2 weeks or longer</td>
</tr>
<tr>
<td>Focus on process vs. product</td>
<td>Students work in teams and relationships with community are developed</td>
</tr>
<tr>
<td>1-3 days long</td>
<td>21st Century skills</td>
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### What is PBL?

Learners go through a **systematic teaching method** that engages them in learning knowledge and skills through an extended inquiry process structured around complex, authentic questions and carefully designed products and tasks.

**Core Principles and Practices of PBL**

1. Professional culture of trust, respect, and responsibility
2. Focus on 21st Century Skills as well as content standards
3. Implementing student-centered instruction to increase relevance and rigor
4. Curriculum designed to connect learning to other subject areas
5. Infusion of technology as a tool for communicating, collaborating and learning
6. Partnerships with community, higher education, and business

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**Doing Projects vs. PBL**

[Diagram showing the difference between doing projects and PBL]

- **Practice Problems**
- **Lecture**
- **Class Discussion**
- **Culminating Project**

- **Entry Document**
- **Driving Question**
- **Results Evaluation**
Entry Event

The entry event should accomplish 5 things:

1. Hook the students
2. Give students their role
3. Lay out project or problem to be completed or solved
4. Give clues for the students to research and ask questions about (NTKs)
5. Align with the project rubric

Rubric

- Holistic rubric
- Consists of several criteria (rows) with creative title (columns)
- Include 1-2 21st century skill to assess and teach
- Language in rubric is objective and clear
Where are the key PBL tools in the Problem Solving Process?

<table>
<thead>
<tr>
<th>STEPS</th>
<th>TOOLS</th>
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<tbody>
<tr>
<td>Phase 1: Define the Problem</td>
<td>Entry Event, Knows &amp; Need-to-Knows, Driving Question, Group Contracts</td>
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<tr>
<td>Phase 2: Solution Criteria</td>
<td>Standards, Rubric</td>
</tr>
<tr>
<td>Phase 3: Solution Research</td>
<td>Community Partner, appropriate activities and content scaffolding, 21st century skill scaffolding, proposals</td>
</tr>
<tr>
<td>Phase 4: Select a Solution</td>
<td>Protocols for feedback on ideas, evaluation and decision-making tools, rubric</td>
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<tr>
<td>Phase 5: Implement and Run Solution</td>
<td>Final products</td>
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<tr>
<td>Phase 6: Reflect on Solution</td>
<td>Self-assessment, summative assessments, class reflection</td>
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I’m Hair to Help: A Unit on Philanthropy and Linear Equations

Julie Evans
Driving Question

As philanthropists, how can we determine the amount of time necessary to grow our hair long enough to donate it to Locks of Love?

Entry Event

- Guest Speaker

Someone who has benefited from Locks of Love
Standards Addressed

- Interpreting Functions (HSF.IF)
- Building Functions (HSF.BF)
- Linear, Quadratic and Exponential Models (HSF.LE)
- Some number, algebra, and statistics standards and some mathematical practices are also addressed.

Mathematical Practices Addressed

- MP1: Make sense of problems and persevere in solving them. Students worked on this challenge for an extended period of time.
- MP3: Construct viable arguments and critique the reasoning of others. Preparing a team presentation to share their findings with their classmates and answer their questions.
- MP4: Model with mathematics. Created a linear model to represent the situation and mathematically articulating several possible scenarios.
Rubric

<table>
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<tr>
<th>Criteria</th>
<th>Overall Performance Standards (Below)</th>
<th>So-So Standards (Minimal)</th>
<th>Hair-Raising Heroes (Demonstrates Exceptional Performance)</th>
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<tbody>
<tr>
<td>0-2</td>
<td>3-5</td>
<td>6-8</td>
<td>9+</td>
</tr>
<tr>
<td>Writing</td>
<td></td>
<td></td>
<td></td>
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<td>Math</td>
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<td>0-2</td>
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<td>6-8</td>
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Sample Product

\[ y = 0.5x + 1.25 \]

- Alex has an average hair growth rate (1/2 inch per month).
- Alex’s hair is 1.25 inches long right now.
Sample Product Continued

So, how long would it be before Alex could donate his hair to locks of love???

\[
12.25 = 0.5x + 1.25 \\
-1.25 & -1.25 \\
\hline \\
11 = 0.5x \\
0.5 & 0.5 \\
\hline \\
22 = x \\
\]

So, it would take Alex about 22 months to grow his hair long enough to donate to locks of love.

21st Century Workplace Skills

- Collaboration and decision-making
- Learning and applying social skills to navigate group interactions
- Using technology for learning and communicating
- Investigating dilemmas using problem solving and critical thinking skills
- Using communication skills to present information generated through investigation, research, and reasoning
- Developing an understanding of and empathy for another (ethics)
- Working together to take action regarding a social dilemma (civic responsibility)
Reflection from Julie Evans

Solar Cooking with Conics

As sustainability scientists, how do we use the properties of conic sections to serve hot soup outside on a winter day with no electricity or heat source other than the sun?
Standards Addressed

Common Core Standards
- HSG.GPE.A.1: Derive the equation of a circle of given center and radius using the Pythagorean theorem; complete the square to find the center and radius of a circle given by an equation.
- HSG.GPE.A.2: Derive the equation of a parabola given a focus and directrix.
- HSG.GPE.A.3: Derive the equations of ellipses and hyperbolas given the foci, using the fact that the sum or difference of the distances from the foci is constant.
- HSG.GMD.B.4: Visualizing relationships between two dimensional and three-dimensional (3-D) objects.
- HSG.MG.A.1 and HSG.MG.A.3: Applying geometric concepts in modeling situations.
- HSA.SSE.B.3: Writing expressions in equivalent forms to solve problems.
- HSF.IF.B.4: Interpreting functions that arise in applications in terms of the context.
- HSF.IF.C: Analyzing functions using different representations.

Standards for Math Practice
- Make sense of problems and persevere in solving them.
- Reason abstractly and quantitatively.
- Use appropriate tools strategically.
- Look for and express regularity in repeated reasoning.
Focused Lessons

- Day 1 & 2: Launching the Project
- Day 5: Headlamp
- Day 7: United Nations Article
- Day 15: Celebration

21st Century Skills

- Written Communication
- Oral Communication
- Collaboration
- Critical Thinking
- Work Ethic
- Striving for Accuracy and Precision (Habit of Mind)
- Creating, Imagining, and Innovating (Habit of Mind)
March 1, 2013
Dear Ben Davis University Scholars,

The world isn’t getting any bigger. But the human population is, and with more people comes more needs and a greater strain on our planet. We already can’t feed 7 Billion of us, and the United Nations now predicts that the world population will grow to 10 billion by 2100.

Despite food, the energy needs required to maintain the lives of 10 Billion people for several decades is raw materials we are currently able to produce. In fact, all of the world’s food in one year, we would already be in a financial crisis. How will we become a sustainable society? What ways stem of food and energy are we currently not taking advantage of?

Pogue Run Cooperative Grocer is a community-owned business devoted to creating a local food economy that benefits our local environment and local business. We have no owner or CEO. Our profits are reinvested in our business or distributed equally to our members. We will like you focus on the properties of scientific terms to create a solar cooker that can be used to harness the power of the sun to heat food. The cooker will be displayed at the University of Indianapolis and at Pogue Run.

Your teacher, Ms. Gossman, has agreed to supervise this project, but it’s up to you students to learn about cosmos and design and build the cooker. You will test the cooker at an event your school. I will be there to make sure the cooker is safe and well-built. We will donate 10% of your event sales to your families and families of students. Make sure to keep a project journal so you can keep track of your progress and show your teachers and me all that you have learned. I suggest that you research local and state sustainability issues and use the site of solar cookers around the world.

I’m sure your test lab there is a need to know to complete the project. Our resources and consult with Ms. Gossman. I’m really looking forward to seeing what you come up with!

Sincerely,

Sara Rubbo
General Manager
Pogue Run Cooperative Grocer
267 E. 13th Street
Indianapolis, IN 46202
317-326-4935

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**Rubric**

<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>Unsustainable (Barely Passing - C)</th>
<th>Sustainability Student (Acceptable - B)</th>
<th>Sustainability Scientist (Excellent - A)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Costed Theory</strong> (40%)</td>
<td>• Shows evidence of deep understanding of the geometric description and the equation for most cone sections (circle, parabola, ellipse, and hyperbola) • Shows evidence of understanding how to translate between the geometric description and the equation for most cone sections (circle, parabola, ellipse, and hyperbola) • Shows evidence of understanding how to translate between the geometric description and the equation for most cone sections (circle, parabola, ellipse, and hyperbola)</td>
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<td><strong>Project Journal</strong> (20%)</td>
<td>• Submits incomplete project collections, evidence of cooperation, research, etc. • Missing basic requirements (should be provided) • Journal is unorganized or messy</td>
<td>• Submits complete project collections, evidence of cooperation, research, etc. • Journal is organized or clean</td>
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<tr>
<td><strong>Mark-Div and Collaboration</strong> (20%)</td>
<td>• Misses 2 or more classes during (announced) • Regularly prefers collaboration over individual work • Assignments completed beyond due dates • Is tardy engaged in same phases of the project process • Sometimes participates in group activities</td>
<td>• Misses 1 or more classes during (announced) • Regularly prefers collaboration over individual work • Assignments completed by due dates • Is tardy engaged in same phases of the project process • Always participates in group activities</td>
<td>• Attends all classes during (announced) • Always follows course requirements • Assignments completed by due dates and provides aid to other students • Is actively engaged in all phases of the project process and is able to lead discussions when necessary • Is a leader in group activities</td>
</tr>
<tr>
<td><strong>Individual Presentation</strong> (20%)</td>
<td>• Does not submit written presentation with instructor • Attends solar cooking event dressed casually • Attends solar cooking event dressed professionally • Presented project in event and is able to report prepared</td>
<td>• Attends individual presentation with instructor and is prepared to discuss content and project • Attends solar cooking event dressed professionally • Presented project at solar cooking event and is able to report prepared</td>
<td>• Attends individual presentation with instructor and is prepared to discuss content and project • Attends solar cooking event dressed professionally • Presented project at solar cooking event and is able to report prepared</td>
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<tr>
<td><strong>Cooked Constructiveness and Functionality</strong> (15%)</td>
<td>• Cooker cannot heat soup to 160°F within two hours • Cooker is unstable and inefficient</td>
<td>• Cooker heats to 160°F within two hours • Cooker is ready to eat</td>
<td>• Cooker heats to 160°F within one hour and a half hours • Cooker is stable and efficient</td>
</tr>
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**GROUP VALUE**

• Submits incomplete project collections, evidence of cooperation, research, etc. • Missing basic requirements (should be provided) • Journal is unorganized or messy • Attends all classes during (announced) • Always follows course requirements • Assignments completed by due dates and provides aid to other students • Is actively engaged in all phases of the project process and is able to lead discussions when necessary • Is a leader in group activities
STANDARDS AND PRACTICES

- **Problem-Based Learning within PBL (Challenge Packet)**

3. A headlight is being constructed in the shape of a paraboloid with depth four inches and diameter five inches.

Sketch a diagram of the headlamp. Then determine the distance d that the bulb should be from the vertex in order to have the beam of light shine straight ahead.

(Breadcrumbs)

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STANDARDS AND PRACTICES

- **Scaffolding with GeoGebra**

\[
(x - 2.5)^2 = 1.13y
\]

\[
A = (0.66, 3) \quad B = (4.34, 3)
\]

Move the slider on the slide to transform the parabola into the red parabola and create a model of the headlamp.

Notice the changes in points A and B and how they affect the green equation of the parabola.

What does \( c \) represent? Look at the coefficient of \( y \) in the green equation of your parabola. How can you interpret this coefficient?

- Click C to show solution.
AT THE SAME TIME, KIDS ARE...

Solar Cooking for Sustainability
Come support BDU math scholars and the Art Club’s Bowl Sale!

Where: OUTSIDE Ben Davis University High School
1101 S High School Rd.
Indianapolis, Indiana 46205

What: Friday April 20th, 11:00am - 1:00pm
Relay for Life: Monday April 23rd, 11:00am

What: In celebration of Earth Day, we are testing
our recently constructed solar cooker and selling
etched glass bowls designed and made by the
Art Club to raise money for the local food bank.

April 22, 2015
Cooking with solar power
BDU students mark Earth Day with project

By Brenda L. Holmes
CNHI

INDIANAPOLIS — Earth Day was
celebrated in style Monday, when students
held a solar cooking demonstration at Ben
Davis University High School. The project
was completed by the college algebra
students lead by student teacher Jacob
Goodman.

"We were learning about conic sections,"
Goodman said. "We studied the parabola
and its special properties. They researched
parabolic solar cookers and had to come up
with their own design ideas."

There are 125 students who completed the
project over a four-week period.
PBL Group Support

1. Take turns sharing with your group one or more challenges you are facing to transition into PBL
2. Group members brainstorm to come up with ideas to help you make that transition.
3. One person will report out what was discussed.

Movies with Math

Choose a movie that you identify with.
Go to the area of the room with that letter: A-E.
Consider switching if you see a group appears to be too large.
**PBL Group Support**

1. Take turns sharing with your group one or more challenges you are facing to transition into PBL
2. Group members brainstorm to come up with ideas to help you make that transition.
3. One person will report out what was discussed.

**What are the Next Steps?**

- Try to design and implement PBL with three R’s in mind:
  - Rigor
  - Relevance
  - Relationships
**Rigor**

- Driving Question is Derived from specific content standards (national, state, or school district)
- Demands depth and breadth of specific knowledge of central concepts
- Students develop new habits of mind (e.g., posing problems, persistence, precision of language)

**Relevance**

- The problem or question has meaning for the students
- Adults in the real world are likely to tackle the problem addressed by the project
- There is an external audience for students work
Relationships

Recognizing that quality work results when students work effectively with their own assets, with their peers, and with adults who have expertise on the topic related to the problem.

- Working with one’s self – realization of one’s assets
- Working with peers – effective teaming
- Working with others – subject matter experts

The Six A’s

1. Authenticity
2. Academic Rigor
3. Applied Learning
4. Active Exploration
5. Adult Connections
6. Assessment Practices
1. **Authenticity**
   - Adults are likely to tackle the “real world” problem
   - Problem/question has meaning to the students

2. **Academic Rigor**
   - Project demands breadth and depth of knowledge of concepts
   - Students develop new habits of mind

3. **Applied Learning**
   - Students apply new knowledge to a real, complex problem
   - Students use multiple high-performance work organization skills
   - Students formally use self-management skills

4. **Active Exploration**
   - Students do field-based activities
   - Students gather info from various primary sources, use various methods

5. **Adult Connections**
   - Students have multiple contacts and interactions with experts

6. **Assessment Practices**
   - Variety of assessments used to monitor progress
   - Frequent and timely feedback given
   - Final product culminates in front of audience
RRR & the Six As

**Rigor**
Related to three of the Six As (Academic Rigor, Applied Learning, Assessment)

**Relevance**
Related to three of the Six As (Authenticity, Applied Learning, Active Exploration)

**Relationships**
Related to two of the Six As (Active Exploration, Adult Connections)

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NCTM Author Talk Webinar

https://www.nctm.org/webinars/author-talks/

*Rigor, Relevance and Relationships: Making Mathematics Come Alive with Project-Based Learning*

March 7, 2018 | Speakers: Jean S. Lee and Enrique Galindo

- Access Recording
- Download Webinar Chat (PDF)
Additional Resources

www.edutopia.org

Additional Resources

www.mathalicious.com

Additional Resources

hightechhigh.org/projects

magnifylearningin.org
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