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

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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)

Problem-Based Learning	Project-Based Learning
Standards-based	
Solutions should allow for multiple strategies	
Specific task or problem	Open-ended Driving Question
Focus on process vs. product	Focus on product AND process
1-3 days long	2 weeks or longer
Students may work in pairs	Students work in teams and relationships with community are developed
Problem solving skills	21st Century skills

What is PBL?

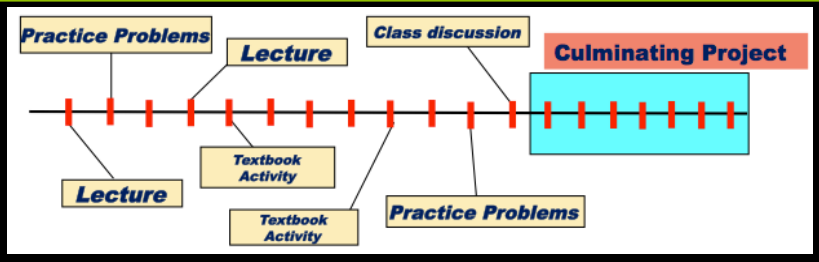
Learners go through a **systematic teaching method** that engages them in learning knowledge and skills through an extended inquiry process structured around complex, authentic questions and carefully designed products and tasks.

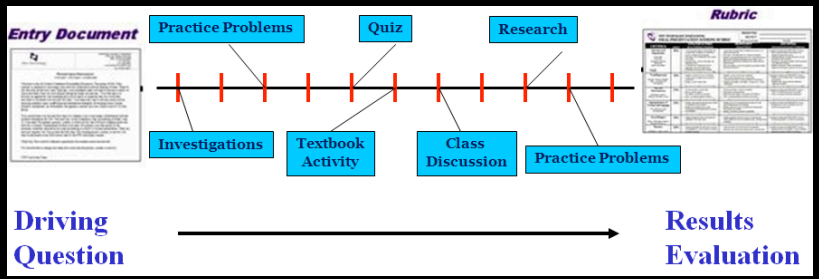
Markham, T., Larmer, J., & Ravitz, J. (2003). *Project-based learning handbook: A guide to standards-focused project based learning, 2nd edition.* Novato, CA: Buck Institute for Education. Pg. 4

+ 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

Doing Projects vs. PBL





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?

STEPS	TOOLS
Phase 1: Define the Problem	Entry Event, Knows & Need-to-Knows, Driving Question, Group Contracts
Phase 2: Solution Criteria	Standards, Rubric
Phase 3: Solution Research	Community Partner, appropriate activities and content scaffolding, 21st century skill scaffolding, proposals
Phase 4: Select a Solution	Protocols for feedback on ideas, evaluation and decision-making tools, rubric
Phase 5: Implement and Run Solution	Final products
Phase 6: Reflect on Solution	Self-assessment, summative assessments, class reflection

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.

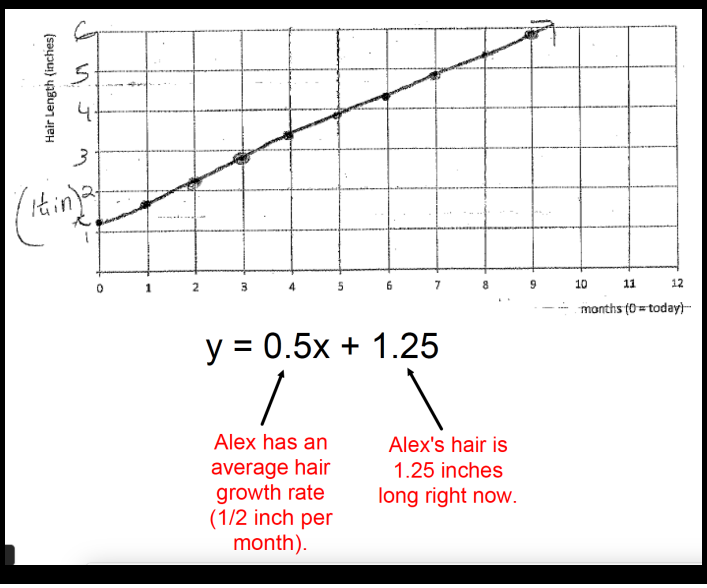
Mathematical Practices Addressed

- 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

Criteria	Failing Frizzies (Below Performance Standards)	So-So Strands (Minimal Criteria)	Hair-Raising Heroes (Demonstrates Exceptional Performance)
Math Reasoning (30%)	• Is able to recognize linear equations • Fails to create a linear equation from the given data • Can solve the equation, but cannot communicate how this relates to an individual person's donating timeline	• Creates a linear equation from the given data • Can solve the equation and somewhat communicate how this relates to an individual person's donating timeline • Can articulate, mathematically, the importance of starting hair length	*In addition to meeting the ACCEPTABLE (So-So Strands) criteria:* • Exhibits the breadth and depth of specific knowledge of central concepts required by this problem • Can articulate, mathematically, the importance of desired ending hair length • Discusses the impact of a potential haircut on donation timeline
	0 - - - - - - - - - - - 9 - - - - - - - - - - - 18	19 - - - - - - - - - - - 22 - - - - - - - - - - - 26	27 - 30
Work Ethic and Collaboration (20%)	• Completes assignments only with encouragement • Completes assignments when class time is available, but does not do work outside of class • Is unengaged and unproductive during class discussions • Submits assignments after deadlines	• Comes to class prepared • Contributes meaningfully to small-group discussions • Completes in-class assignment with steady focus • Does not create distractions for other students • Participates in group presentation • Completes out-of-class assignments with accuracy and detail • Completes peer and self-evaluations	*In addition to meeting the ACCEPTABLE (So-So Strands) criteria:* • Exhibits leadership, regardless of project role • Seeks constructive feedback prior to project deadlines • Makes adjustments to improve project performance as recommended by instructor
	0 - - - - - - - - - - - 6 - - - - - - - - - - - 12	13 - - - - - - - - - - - 15 - - - - - - - - - - - 17	18 - - - - - - - - - - - 19 - - - - - - - - - - - 20
Final Presentation (50%)	• Body language: – Facial expressions distract from presentation – Not enthusiastic – Eye contact not maintained • Speech: – Volume too loud/too soft for setting – Words are not enunciated – Pace of speech is difficult to understand – Uses filler words (uh, um, like) • Presentation is less than five minutes • Not all members participate • Presentation is mostly data and is nonpersuasive • Members do not answer the audience's questions • Members depend mostly on notes	• Body language: – Uses some enthusiasm (smile, inflection) – Eye contact maintained • Speech: – Volume is appropriate for setting – Words are enunciated, and speech is understandable – Uses minimal filler words (uh, um, like) • Presentation is at least five minutes • All members participate in some capacity • Presentation is persuasive and uses data but not cohesively • Members mostly answer the audience's questions • Members use some notes	*In addition to meeting the ACCEPTABLE (So-So Strands) criteria:* • Body language: – Gestures, stance, and expressions enhance presentation – Talks directly to audience members who ask questions, as well as pulls others in • Speech: – Has enthusiasm and clarity – Avoids filler words (uh, um, like) • All members participate equally • Members do not read from notes • Presentation uses data to persuade, information is fluid, and transitions from data to persuasiveness are smooth and well-rehearsed • Members answer the audience's questions completely and correctly (mathematically)
	0 - - - - - - - - - - - 15 - - - - - - - - - - - 30	31 - - - - - - - - - 37 - - - - - - - - - - 44	45 - - - - - - - - - 47 - - - - - - - - - 50

+ Sample Product



Sample Product Continued

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

12.25 inches is how long Alex's hair would have to be before he would cut it because he wants to have 1.25 inches left after it's cut and we are allowing 11 inches to be cut (just to be safe).

$$12.25 = 0.5x + 1.25$$
$$-1.25 \qquad -1.25$$

$$\frac{11}{0.5} = \frac{0.5x}{0.5}$$

$$22 = x$$

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

Jacob Goodman

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 Addressed

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)

Entry Event

March 7, 2013

Dear Ben Davis University Scholars,

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

Besides food, the energy needs required to maintain the lives of 10 billion people far exceeds what we are currently able to produce. In fact, if everyone in the world consumed as much energy as Americans, we would already be in an energy crisis. How will we become a sustainable species? What sources of food and energy are we currently not taking advantage of?

Pogue's Run Cooperative Grocer is a community-owned business invested in creating a local food economy and being a model for sustainable business. We have no owner or CEO. Our profits are reinvested in our business or distributed equally to all of our members. We would like you to use the properties of conic sections 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's Run.

Your teacher, Mr. Goodman, has agreed to supervise this project, but it's up to you scholars to learn about conics and design and build the cooker. You will test the cooker at an event at your school. I will be there to make sure the cooker is safe and well-built. We will donate soup for your event, and you will serve that soup to your families and faculty at school. Make sure to keep a project journal so you can keep track of your progress and show your teachers and me all that you've learned. I suggest that you research local and global sustainability issues and the use of solar cookers around the world.

I'm sure you feel like there's a lot you need to know to complete this project. Be resourceful and consult with Mr. Goodman. I'm really looking forward to seeing what you come up with!

Sincerely,

Nate Roberts
General Manager
Pogue's Run Cooperative Grocer
2828 E. 10th Street
Indianapolis, IN 46201
317-426-4963

Rubric

CRITERIA	Unsustainable (Barely Passing - C)	Sustainability Student (Acceptable - B)	Sustainability Scientist (Excellent - A)
Content Mastery (40%)	• Shows evidence of broad understanding of the geometric description and/or the equation for most conic sections (circle, parabola, ellipse, and hyperbola) • Developing visualization of relationships between the cone and some of its two-dimensional cross-sections. • Partially applies geometry in modeling the solar cooker. • Some evidence of interpreting quadratic functions that arise in applications. • Writes quadratic expressions in equivalent form. • Analyzes functions using at least one representation. • Earns between 70%-79% on final quiz	• Shows evidence of understanding how to translate between the geometric description and the equation for most conic sections (circle, parabola, ellipse, and hyperbola) • Shows evidence of visualizing relationships between the cone and some of its two-dimensional cross-sections. • Applies geometry in modeling the solar cooker. • Interprets quadratic functions that arise in the context of creating the solar cooker. • Writes quadratic expressions in equivalent form to solve problems. • Analyzes functions using at least two representations. • Earns between 80% and 89% on final quiz	• Shows evidence of deep understanding of how to translate between the geometric description and the equation for all conic sections (circle, parabola, ellipse, and hyperbola). • Shows evidence of visualizing relationships between the cone and its two-dimensional cross-sections. • Applies geometry in modeling the solar cooker in an efficient and sophisticated way. • Interprets quadratic functions that arise in applications in terms of the context. • Analyzes functions using multiple representations. • Earns 90% or higher on final quiz
Project Journal (30%)	• Submits incomplete journal: reflections, evidence of exploration, research, etc. missing (base requirements checklist will be provided) • Journal is unorganized or messy • Brings journal to class irregularly	• Submits completed journal with base requirements • Journal is organized • Brings journal to class regularly	• Submits completed journal with base requirements and at least 1 additional article and 1 additional reflection (prompts to be provided) • Journal is organized and stylish (graphics, color, etc…) • Always brings journal to class and uses it as a resource
Work Ethic and Collaboration (10%)	• Misses two or more classes during unit (unexcused) • Regularly performs outside on contractual norms • Assignments completed beyond due dates • Is actively engaged in some phases of the project process • Sometimes participates in group activities	• Misses one class during unit (unexcused) • Rarely performs outside of contractual norms • Assignments completed by due dates • Is actively engaged in all phases of the project process • Always participates in group activities	• Attends all classes during unit • Always follows contractual norms • 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 discussion when necessary • Is a facilitator of group activities
Individual Presentation (15%)	• Does not attend informal presentation with instructor • Attends solar cooking event dressed casually • Is disengaged from guests at solar cooking event • Presents journal to event guest and is rated as semi-prepared	• Attends informal presentation with instructor somewhat prepared to discuss content and project • Attends solar cooking event dressed professionally • Engages guests at solar cooking event • Presents journal to event guest and is rated as prepared	• Attends informal presentation with instructor and is prepared to discuss content and project • Attends solar cooking event dressed professionally and smiling • Invites guests to event and mingles during event • Presents journal to event guest and is rated as very prepared
Cooker Construction and Functionality (5%)	• Cooker cannot heat soup to 165°F within two hours • Cooker is unstable and tattered • Cooker cannot be constructed within budget	• Cooker heats soup to 165°F within two hours • Cooker is stable • Cooker is constructed with given budget	• Cooker heats soup to 165°F within one and a half hours • Cooker is stable and attractive (clean lines, attention to detail, decorations, etc…) • Cooker is constructed below budget
GROUP GRADE			

STANDARDS AND PRACTICES

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

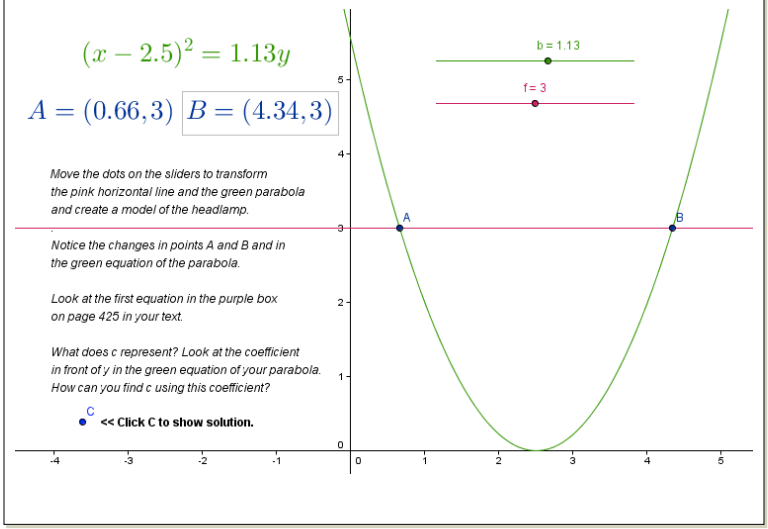
3. A headlight is being constructed in the shape of a paraboloid with depth four inches and diameter five inches.

   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)

STANDARDS AND PRACTICES

- **Scaffolding with GeoGebra**



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
1155 S. High School Rd.
Indianapolis, Indiana 46241

When: Friday April 19th 11:45am - 1:00pm

Rain/Cloud Date: Monday April 22nd (same time)

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, 2013

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.

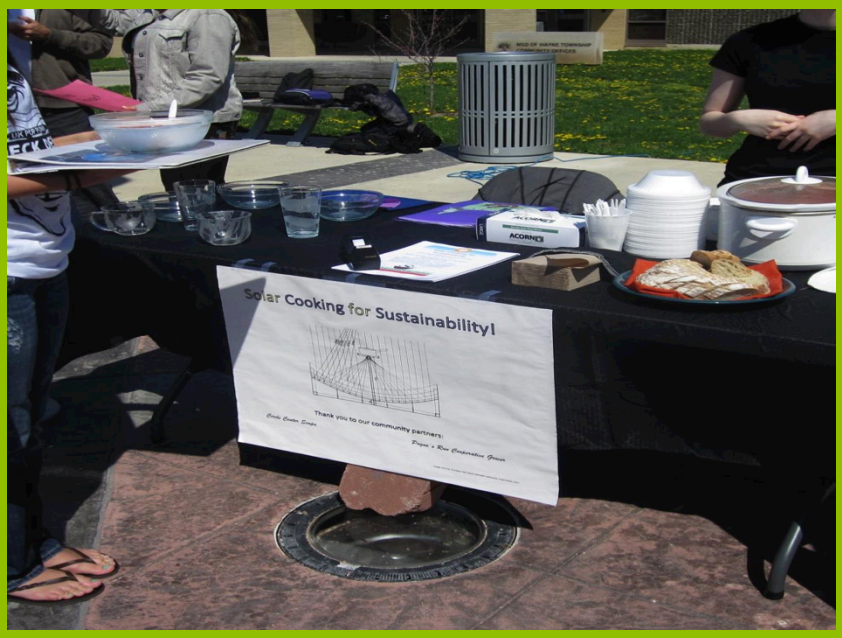
"We were learning about conic sections," Goodman said. "We studied the parabola and its special properties. They researched parabolic solar cookers and had to come up with their own design ideas."

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

Related Photos

Students and visitors check out a solar cooker created by the college algebra classes at Ben Davis University High School.
Brenda L. Holmes/Flyer photo

Kaitlyn Osborn explains her project journal.
Brenda L. Holmes/Flyer photo


Solar Cooking for Sustainability!
Thank you to our community partners:

Video of Jacob Goodman

PBL Support Group

PBL Group Support

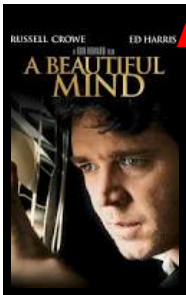
1. Take turns sharing with your group one or more challenges you are facing to transition into PBL
2. Group members brainstorm to come up with ideas to help you make that transition.
3. One person will report out what was discussed.

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.

A



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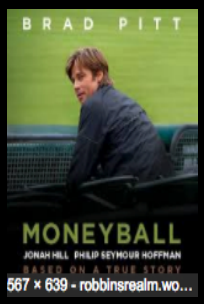

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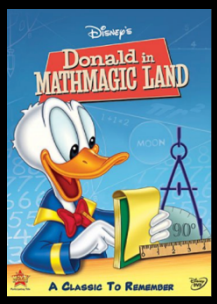


E

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

The Six A's

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

The Six A's

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

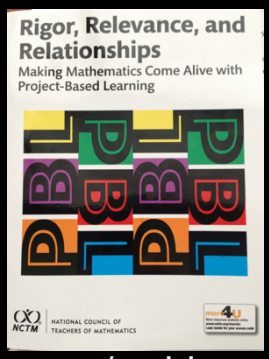
RRR & the Six As

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)

NCTM Author Talk Webinar



https://www.nctm.org/webinars/authortalks/

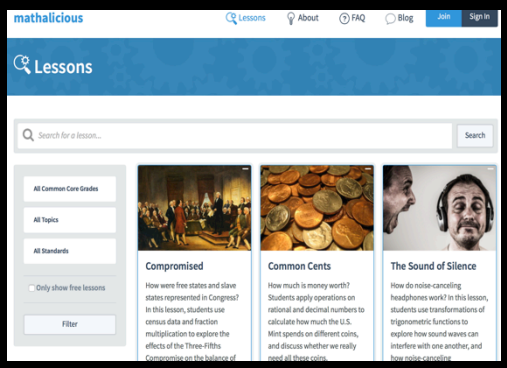
Rigor, Relevance and Relationships: Making Mathematics Come Alive with Project-Based Learning

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

Access Recording Download Webinar Chat (PDF)

Additional Resources

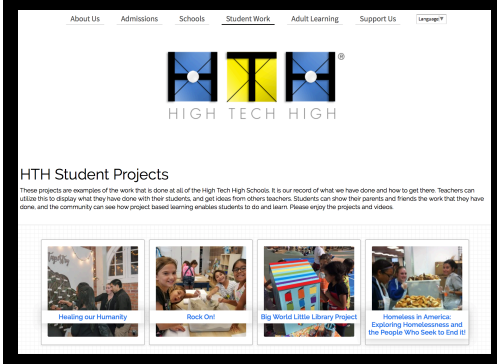
www.edutopia.org

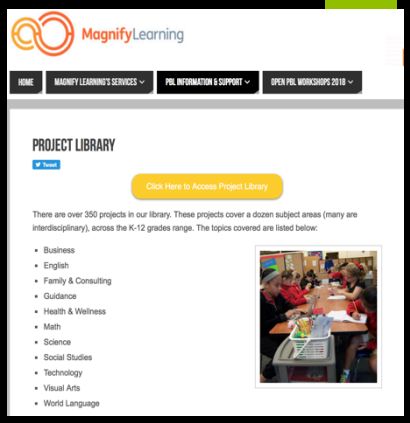


www.mathalicious.com

+ Additional Resources

hightechhigh.org/projects

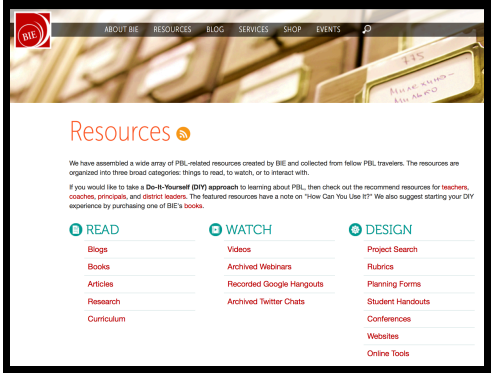




magnifylearningin.org

Additional Resources

www.bie.org



archive.pbl-online.org

Questions?

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