Problem-based Learning
Winter Faculty Institute 2016

Delayne Y. Johnson
Prior PBL experience

- Active learning, student-centered, inquiry-based lessons
- Groups of 3-4 assigned by instructor based upon survey data
- Build on students’ prior knowledge
- Develops mathematical proficiency (NRC, 2001)
- Clear, precise, measurable learning goals in terms of student thinking
- Aligned with mathematical standards and practice (NCTM, 2000; CCSSM, 2010)
The Alphabetic Project

The Problem
Imagine that you are a member of a small tribe that lived thousands of years ago, when people were making the transition from being hunter-gatherers to farmers. You have a numeration system that is alphabetically based, so you are called Alphabeticians. Like many other ancient peoples, your numeration system only works well up to a certain amount or quantity. So, for any amount greater than Z, you have no symbol at all.

<table>
<thead>
<tr>
<th>Amount</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>...</th>
<th>J</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alphabetian numeral</td>
<td>*</td>
<td>*</td>
<td>***</td>
<td>***</td>
<td>****</td>
<td>...</td>
<td>**</td>
<td>**</td>
</tr>
</tbody>
</table>

Now that your tribe has settled down, you have "many" cows and "many" bags of wheat. Without an adequate numeration system, figuring out how many more cows you have this year than last year and determining each family's share of the wheat harvest is very tedious. A young woman in your tribe had excitedly announced that she had invented a new counting system with which she can represent any amount using only the symbols A, B, C, D, E and a new symbol she calls zero and writes as 0. Unfortunately for your tribe, she died on a hunting trip. So, your tribe still has a big problem and really needs a better way of representing quantities.

You need a new numeration system. Since the visionary member of your tribe is no longer with you, it is up to you to figure out her numeration system. Here is an additional fact about her numeration system: The numeration system that the young woman invented has the same properties as our Hindu-Arabic numeration system (except for being base-ten).

The Task
Your job is to develop a system that has the same properties as the Hindu-Arabic system (except for base-ten) but uses only the symbols A, B, C, D, E, and 0. You cannot use any other symbols. You may not even use something like the Romans used to multiply by one thousand. Be sure that you can explain how your system works. In addition, represent the following quantities using your numeration system:

(a) *** (We call this quantity "six.")
(b) ********* (We call this quantity "ten.")
(c) .......................................................... (We call this quantity "thirty-eight.")
(d) The quantity that we call "seven hundred seventy-seven."
(e) The quantity that we call "one million."
(f) The quantity that we call "zero."
The Cyber Infused Mathematics Initiative (CIMI)

• A new approach to undergraduate mathematics learning and teaching

• Content is delivered within a real world problem-solving context

• Student-centered, inquiry-based, inverted classroom

• Partners faculty across disciplines

PBL in College Algebra
Problem Writing Worksheet

- Target class and student population:
- Learning Objectives.
  - Content Objectives.
  - Process Objectives.
- Problem Context
- Staging the Problem
  - Stage 1: A hook that encourages students to think more deeply
  - Stage 2: Problem/Task
  - Stage 3: Possible Staging and Guiding Questions

PBL Problem Development
Voters are noticing that Hillary Clinton’s Instagram followers have been on the decline since June 1, 2015. She lost 7,500 Instagram followers after presenting for 15 minutes at an election event. She also lost 4,200 followers after speaking for 40 minutes.

To prevent losing any followers, how long should Hillary speak?

To prevent losing more than 1000 follower, how long should Hillary speak?

Explain the rate at which Hillary loses followers.

Express this information graphically, symbolically, and verbally.

Your team is responsible for managing presidential candidate, Hillary Clinton’s, social media campaign. You have noticed that Mrs. Clinton’s Instagram followers have been on the decline since June 1, 2015. She lost 7,500 Instagram followers after presenting for 15 minutes at an election event. She also lost 4,200 followers after speaking for 40 minutes.

Your task is to keep Mrs. Clinton’s social media presence as strong as possible. How will you advise your candidate and her speech-writing team? To justify your advice, answer the following:

1. To prevent losing more than 1000 followers, how long should Mrs. Clinton speak?

2. To prevent losing any followers, how long should Mrs. Clinton speak?

3. Explain the rate at which Mrs. Clinton loses followers.

4. Present a clear argument for your advice by displaying information graphically, symbolically, and verbally.
Student Work: Hillary Clinton’s Social Media Campaign
• “This class really makes you understand the math.”

• “I took College Algebra before and got a D. What I like about this is that it’s not just someone talking at you. You get to work on problems and ask questions when you have them.”

Student Feedback
PBL in Developmental Mathematics Courses

Equity:
- PBL shows promise as a strategy that supports equity by engaging lower-achieving students. (Boaler, 2002; Penuel & Means, 2000)

Motivation:
- In PBL classrooms, students demonstrate improved attitudes toward learning. They exhibit more engagement, are more self-reliant, and have better attendance than in more traditional settings. (Thomas, 2000; Walker & Leary, 2009)

Academic achievement:
- Students retain content longer and have a deeper understanding of what they are learning. (Penuel & Means, 2000; Stepien, Gallagher & Workman, 1993)
- PBL has been shown to be more effective than traditional methods for teaching math, economics, language, science, and other disciplines. (Beckett & Miller, 2006; Boaler, 2002; Mergendoller, Maxwell, & Bellisimo, 2006)
- Students demonstrate better problem-solving skills in PBL than in more traditional classes and are able to apply what they learn to real-life situations. (Finkelstein, 2010)
- PBL students show improved critical thinking. (Beckett & Miller, 2006; Horan, Lavaroni, & Beldon, 1996; Mergendoller, Maxwell, & Bellisimo, 2006; Tretten & Zachariou, 1995)