Web-based Resources for Adult Mathematics Teachers
Part 2

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OPEN MIDDLE

The Mathematical Practices that are in the Common Core State Standards define what it means to be mathematically proficient. Our job, as adult education instructors, is to help our students navigate over the swells in the tempest of their angst until they get to the point where they have enough confidence in their own abilities to weather the sea of mathematics.

Consider the first standard, MP1: Make sense of problems and persevere in solving them. It explains that our students should be able to approach a math problem or situation — something a bit challenging that they might never have seen before — and find a way into solving it. They should be able to develop flexibility with numbers and the ability to approach problems with the understanding that there are multiple pathways that can lead to a solution. They should have confidence that if they stick with it long enough, they can find an appropriate strategy that will solve the problem. That means that we, as their teachers, need to provide intriguing math problems that catch our students' attention and then nourish and celebrate the different methods of problem solving that our students intuitively gravitate towards. [1]

One resource that ANN recommends for these kinds of math problems is Open Middle. As of this writing, there are over 300 high-interest problems housed at the website. They are organized by grade level and topic that make it easy to zero in on a particular skill level and area of focus that you want to bring into your classroom. What makes a problem *open-middle*? The website explains:

- *They have a "closed beginning" meaning that they all start with the same initial problem.*
- *They have a "closed end" meaning that they all end with the same answer.*
- *They have an "open middle" meaning that there are multiple ways to approach and ultimately solve the problem*. [2]

As an example, consider the following problem. At first glance this may seem pretty straightforward, requiring only a knowledge of the rules of subtraction in order to solve it. Try solving it yourself before going on to the next page. Keep in mind that there is one optimal answer to this problem albeit multiple ways to arrive at this solution.

Subtraction to get the Smallest Difference

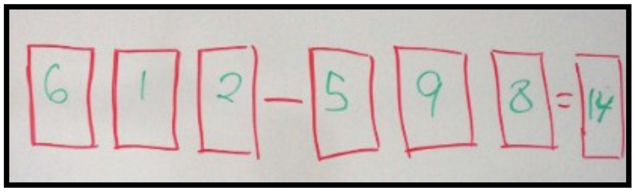
Directions: Place any digit, 1 through 9, in the boxes below to create the smallest possible difference. Each digit can only be used once.

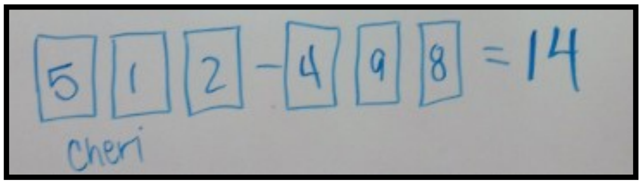
□□□ - □□□ = ?

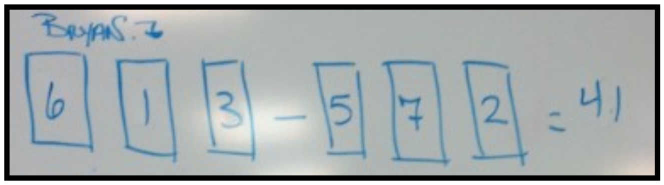
Each problem comes with a hint. For this problem the hint is: *Remember that zeros are not allowed. Because you can only use each digit once, the digit in the hundreds place can't be the same.* [3]

This is listed under Grade 2, so keep this in mind when navigating the website. Don't necessarily start with high-school level if your students need the basics in algebraic thinking and are just beginning to learn how to be flexible with numbers. If you've already worked out a solution to the problem, go on to the next page to see examples of how my students approached this.

Pictured below are three work samples from my students:







Notice that one student did not arrive at the optimal answer on his first try. He was a tad disappointed when he saw that a classmate had found a smaller difference until I asked him if there might be another combination of numbers, besides what his peer had already found, that might lead to the optimal answer of 14. This led to a flurry of renewed interest in the problem as all students, even those whose calculations had already led to 14, busied themselves in trying to discover what other number combinations would work. Two of those solutions are pictured above, which clearly indicate a pattern that can lead to additional solutions.

To wrap up this activity, have each student who discovered the optimal answer of 14 explain how they arrived at their answer. When all solutions that students found are placed on the board, ask students what they noticed about the pattern that is evidenced in the solutions. If they have not already found and commented on the pattern in the combinations of numbers that work, ask students if they see any patterns in the solutions and discuss how the pattern changes with each equation. Recognizing patterns and developing flexibility with numbers go a long way in helping our students to become mathematically proficient.

Open-Ended Problems

Some of the problems on the website are also *open-ended* in that there are multiple, sometimes infinite, answers to the problem. Students may still arrive at their answer via multiple solution pathways, but now everyone in the class has the ability to create and defend their own unique math situation. Table of Values: Function is one such example, which simply asks students to create a table of values that represents a function. This activity can reinforce the basic definition of a function. Many times we focus our instruction on finding the rule of a function when we present a table of values to our students, but it's also important that they are able to look at an input/output table, a graph, a range and domain set with arrow notation, or sets of ordered pairs and correctly identify which ones represent a function and which ones do not.

There may be no readily apparent rule for a set of values that our students might see on an HSE exam, other than it *is* or *is not* a function based on the definition of a function: a relationship between two values where each input value has only one unique output. While having an understanding of this rule is a procedural skill, requiring students to create their own set of values using their choice of an input/output table, graph, range and domain set with arrow notation, or sets of ordered pairs, requires a higher depth of knowledge, especially if students are subsequently tasked to create a real-life scenario that their function represents. Students are more apt to remember the basic definition of a function if they have engaged in this kind of an open-ended activity. As a follow up to this, you can assess student's understanding of a function with the TASC/ORT Style Problem Assessment Packet, aligned to Units 1-4 of the CUNY HSE Mathematics Curriculum Framework.

References:
[1] Mathematical Mindsets, Joe Boaler, 2016

[2] http://www.openmiddle.com/about/

[3] http://www.openmiddle.com/subtraction-to-get-the-smallest-difference/

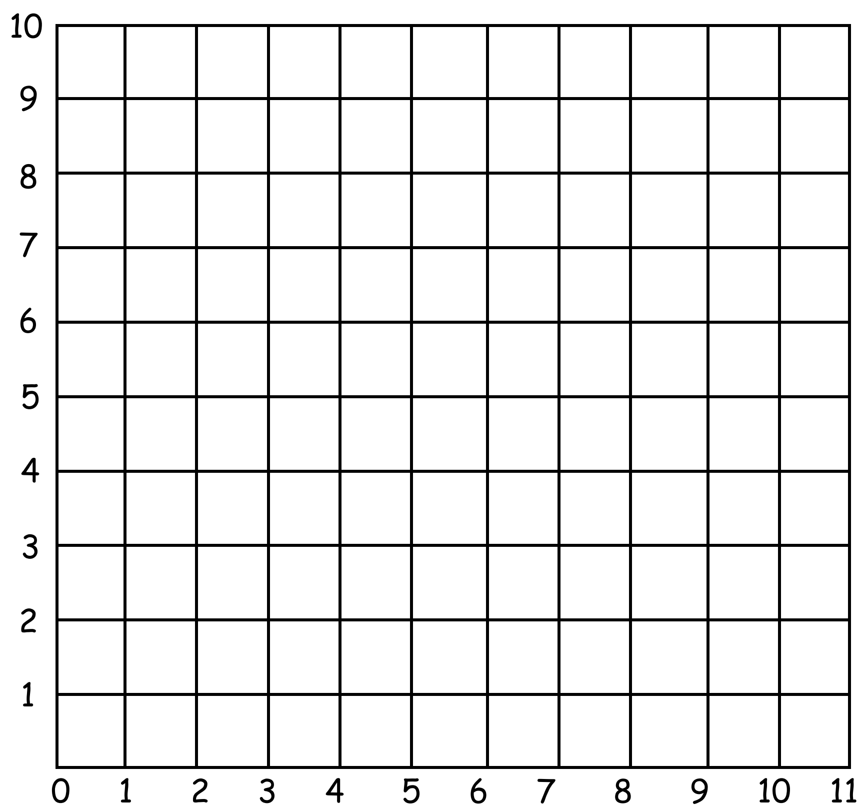
Create Squares

Directions: Create a square with one of the vertices at (2, 3). Fill in the blanks with whole numbers 0 through 9, using each number at most once, to show the rest of the vertices of the square.

(2, 3) (___, ___) (___, ___) (___, ___)

Bonus: Find more than one set of vertices.

(2, 3) (___, ___) (___, ___) (___, ___)



Adapted from Open Middle: http://www.openmiddle.com/create-squares/