Math Games and Problems for Seventh Graders:
Keeping Students Interested and Involved

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Overview

One of the toughest challenges facing math teachers is keeping students interested and involved throughout the year. With the prospect of double periods of math looming in the coming school year, it will be crucial to the achievement of the students and the sanity of the teachers to keep interest high and disruptions low. For many students, math seems unbearably boring and meaningless. Fortunately, there are countless problem-solving activities and math games that a teacher can incorporate into the curriculum to keep the students engaged.

The number of websites and books dedicated to math games and problem-solving is truly extraordinary; you could spend days and days exploring them and not even make a dent. I have tried to streamline that task a bit and target specific activities that are directly related to the Connected Mathematics 2 (CMP2) units that I teach to seventh graders, as well as activities that will help my students become more involved learners.

Rationale

I love math, and I would love my students to love it too. I consider myself a fairly animated and enthusiastic teacher; I try not to drone on and on, and I do all sorts of things to get students involved, such as group projects and hands-on activities. Yet the fact remains that we have a curriculum to follow and the students have a lot to learn: coordinate graphs and linear relationships, scale factor and similarity, ratio and proportions, and much more. The CMP2 books are fantastic, discovery-based units, but they are not easy, and they involve perseverance and sometimes frustration on the part of the students.

Blame it on television, blame it on video games or text messaging or music or bad parenting or whatever; the fact remains that too many kids don't want to work hard, they don't know how to stick with something or work through anything difficult. Their favorite phrase is "I don't get this. I need help." What they really mean is "Give me the answer, because I don't feel like doing it myself."

As my years of teaching have gone by, I have become increasingly frustrated, angered, and even saddened by the lack of any sort of academic values in too many of my students. They don't want to try hard, they can't stand to be frustrated or confused, they copy each other's classwork and homework, and the concept of paying attention in class and participating is totally foreign to them.

I have seen this trend worsen with each passing year, and I must say that this year has been one of my most disheartening years yet. Why do students dislike math so much? What happened somewhere along the line that made them give up and shut down? In a society that places great emphasis on instant gratification and constant entertainment, a teacher can feel like she doesn't stand a chance.

Then again, I often question myself and my delivery of the material; why can't I make the math more interesting and meaningful? Do the students really understand the mathematics, or are they just picking up superficial information?

I refuse to give up or give in, and I feel certain that there are ways to maintain interest and high academic achievement without resorting to bells and whistles and cheap entertainment.

Games and activities are not just fun extras to be used as a reward; they are important learning tools that can help a student learn to think logically and creatively, and they can also help students realize the enormous satisfaction of sticking with something and doing it on their own.

NCTM's journal *Mathematics Teaching in the Middle School* has been a constant source of inspiration and ideas for me, and several years ago I read an article by Tisa M. Lach and Lynae E. Sakshaug entitled "Let's Do Math: Wanna Play?" Using her sixth graders as test subjects, Lach researched the use of math games in the classroom. She had already established that the use of games kept her students more motivated and involved, but she wanted to find out whether or not playing games really increased the students' understanding of math.

She gave the students a pre-assessment at the beginning of the school year, to determine their level of understanding of problem solving in the areas of spatial

sense and algebraic reasoning (p.174). For the next twelve weeks, students were given the chance to play games for thirty minutes every Tuesday and Thursday. Additionally, Lach set up game stations around her room for students to use during a daily twenty-minute activity period. The games she chose were common and relatively simple board and card games: Connect Four, Guess Who, Challenge 24, Tangramables, Rush Hour, and other similar games.

At the end of the 12-week period, Lach gave the same assessment to the students, and they did much better. They also showed a greater ability to solve multi-step problems. Lach also found that students developed more confidence in their math skills. Besides the measurable increases in their problem solving abilities, Lach noticed a marked difference in the overall learning atmosphere of the classroom:

> *Playing games created a more relaxed atmosphere in the classroom and provided opportunities for my students to work things out for themselves, not only mathematically, but also socially. Students had to decide who would go first each time they played a game. They had to decide who would play which games for how long at the centers where there was more than one game. The students had to make choices about how to handle someone who tried to cheat or use a move or strategy that was not accepted by the group. They also cheered for and complimented each other as they played the games. In these ways, the class developed a deeper sense of community and the group was better able to interact socially with each other* (p.175).

Teachers of middle school kids know that it can sometimes be a real struggle to get students to work cooperatively and get along with each other. If a stronger sense of camaraderie and community can be established by playing Muggins or Mastermind, I'm all for it.

Our district uses Connected Mathematics in most of the middle schools. Some schools piloted CMP2 (Connected Math 2) last year, and this coming school year the CMP2 curriculum will be district-wide, along with skills-based worksheets and enrichment activities.

In the CMP2 Implementing and Teaching Guide, they state that the overarching goal of Connected Mathematics is to help students develop mathematical knowledge, understanding, and skill.

> *All students should be able to reason and communicate proficiently in mathematics…including the ability to define and solve problems with reason, insight, inventiveness, and technical proficiency(p.2).*

In the past, I have often felt pressure to stick closely to the pacing chart

and not do anything extra. I'm looking forward to having 90-minute periods with my students in the coming school year (as opposed to the previous 42-minute class). Connected Math has plenty of fun investigations and projects for students, but I am certain that the curriculum can benefit from the addition of games, puzzles, and activities that I have found outside of the CMP2 realm.

The National Council of Teachers of Mathematics states that the Standards for School Mathematics are "descriptions of what mathematics instruction should enable students to know and do" (p.28). Along with the Content Standards (mathematical strands) that I discuss in the Objectives section, the NCTM includes what it calls the Process Standards: Problem Solving, Reasoning and Proof, Communications, Connections, and Representation. The Process Standards describe ways of acquiring and using content knowledge.

The explanations of the Process Standards are, as expected, quite detailed and involved. The following descriptions of the standards are simplified and brief, but they do give a sense of what the NCTM recommends.

Instructional programs should enable all students to:

Build new mathematical knowledge through problem solving (p.256).
Recognize reasoning and proof as fundamental aspects of mathematics (p.262).
Organize and consolidate their mathematical thinking through communication (p.268).
Understand how mathematical ideas interconnect and build on one another to produce a coherent whole (p.274).
Create and use representations to organize, record, and communicate mathematical ideas (p.280).

The Pennsylvania Department of Education's Academic Standards for Mathematics are slightly different from those proposed by the NCTM (see Appendix A), but the differences are mostly in organization and semantics. When referring to specific standards, I will use the PDE version since that is what we use when writing lesson plans.

Math games and problems help students master these standards and build a deeper understanding and appreciation of mathematical concepts. And the best part is, they don't even know they're doing it!

Objectives

There are four mathematical strands that CMP2 develops: Number and Operation,

Geometry and Measurement, Data Analysis and Probability, and Algebra. Each of the strands is covered in the units I do with the students. There are 24 units in CMP2, eight at each grade level. I usually manage to cover five or six of the units each year.

CMP2 is closely aligned with the NCTM *Principles and Standards 2000.* The recommended scope and sequence of the CMP2 units stresses building a deep understanding of required content topics, with an emphasis on problem solving.

CMP2 has identified eleven key "process goals" that describe the kinds of thinking that students should be able to demonstrate after completing the curriculum: counting, visualizing, comparing, estimating, measuring, modeling, reasoning, connecting, representing, using tools, and becoming mathematicians.

All eleven of these process goals can be reached through playing games. Take, for example, two well-known card games; War and Concentration. There are endless variations of both games (Addition War, Subtraction War, Multiplication War, Fraction/Decimal Concentration, etc.). When students play Addition War (two cards are played at once, and added together) they are counting, comparing, measuring, reasoning, and becoming mathematicians. Fraction/Decimal Concentration helps students with visualizing, estimating, connecting, and representing.

The units I teach in seventh grade, and the content each unit covers, are as follows:

Variables and Patterns: representation of relationships using tables, graphs, and symbols (introducing algebra)

Stretching and Shrinking: similar figures and scale factor

Comparing and Scaling: proportional reasoning, ratio and percent

Accentuate the Negative: positive and negative integers, order of operations, four-quadrant graphing

Moving Straight Ahead: representing linear relationships, solving linear equations, slope

Students can make sense of mathematics if the concepts and skills are embedded within a problem. If time is spent exploring interesting mathematical situations and reflecting on the solutions, students are much more likely to develop a robust understanding of mathematical concepts (CMP2 Implementing

and Teaching Guide, p.6).

My objective is to incorporate fun yet challenging math problems and games into my everyday lessons, thereby sparking more interest and enthusiasm in my students, as well as adding to their understanding of math.

Strategies

When I first started researching this unit by looking at math books and investigating the Internet, I quickly realized that the resources for math games, problems, puzzles, and activities are almost endless. You could get lost for days exploring various websites and reading math books.

I needed to find a focus for myself; was I going to present the math games as a separate unit sometime during the school year, or should I incorporate the games into the entire curriculum? Since the objective was to keep both learning and student interest going strong all year, I decided to incorporate into the existing curriculum.

The overall plan includes problems of the day, an activity center full of math books and games, and various activities that can help students get ready for a new unit and review what they have already learned.

The school year will start with the book Math Curse by Jon Scieszka and Lane Smith, which has a great opening line:

> *On Monday in math class, Mrs. Fibonacci says, "You know, you can think of almost everything as a math problem."*

I plan to read this to my students on the very first day of school. It's a wonderful way to set the tone for the entire year.

Along with the usual teaching of classroom procedures and rules, I like to start the year off with some number sense activities and some problem solving. The beginning of the school year is the best time to introduce some problems that require sustained effort and creative reasoning, because that's when the students are on their best behavior and want to impress their teachers.

Throughout the year, I will use a math game or problem as an introduction to each unit, and then again at the end of the unit to reinforce and review some of the key concepts taught.

I will also set up a math activity center, with various math-related books (see bibliography) and board games: Connect Four, Battleship, chess, and so on.

Students will be able to go to the activity center if they finish their classwork or test early, or if I give the class a "free" day (very rare in my classroom).

As I previously mentioned, the math websites are mindboggling; there are so many of them out there, and of course, some of them are useless. There are literally thousands of really good sites, too, like MathPlayground, CoolMath, FunBrain, A+Math, and FirstInMath. Kids love anything that involves the computer, and they really can benefit from playing the Internet games, but that would be a whole other paper. I would never discourage anyone from using online sites with their students, but I don't think they should be used exclusively, because there are so many great "old-fashioned" games for kids to play.

Classroom Activities

The possibilities and resources for activities are endless, but I have fine-tuned my selections to fit in with the CMP2 curriculum and the needs of my students.

Problem Solving

The first week of school (the second or third day), I like to give my students the *Young MacDonald* problem:

> When Young MacDonald was starting his farm a long time ago, cows cost $10 each, pigs cost $3 each, and chickens cost $.50 each. He bought at least one of each kind of animal. He paid $100 for 100 animals. How many chickens did he buy? (Standards 2.4, 2.5, 2.8)

This problem elicits a myriad of reactions from the students: confusion, interest, frustration, anger, and triumph, to name just a few. I have given my classes this problem several times throughout the years, and I always refuse to help them in any way. They struggle for awhile, and I've had kids get very angry with me and say "You're supposed to be *teaching* us," but I'm a firm believer in letting students struggle and find their own way (with, of course, the appropriate level of instruction and scaffolding beforehand). If I see a student really having a hard time, I will ask him what the problem is asking, and then maybe suggest organizing their work with a chart or table. The sense of accomplishment when they finally get the answer is enormous, and kids get very excited when they figure it out. (Answers to problems can be found in Appendix B).

I have an entire binder of these sorts of problems, thanks to the 1995 math department at Milliones Middle School. Some of the problems are much easier, some are deceptively simple, and some are very difficult.

The Brown Paper School creates and publishes great books like Math for Smarty Pants and The I Hate Mathematics! Book, both by Marilyn Burns. They are written for kids and they're a lot of fun to read, with funny pictures and stories. One of the problems in Math for Smarty Pants is called "The Three Little Pig Eyes" (pp.22-28). It is a long involved story, but it's told in an entertaining way, and you could really ham it up (sorry) and make the story into a big deal to build the students' interest. The basic premise is that Sally McCrackin has a bag full of peanuts, but she keeps getting accosted by the three little pig eyes, each one demanding half of her peanuts, plus two more. The only way Sally can get her beloved peanuts back is to guess how many she had originally. Students could work in groups to figure this one out. (2.1, 2.2, 2.4)

Another resource I have for problem solving is the Perplexors series put out by MindWare. The "perplexors" are "logic puzzles for a sharper mind." The books are filled with worksheets that organize all the information needed to solve a logic problem. What they do is list all the possibilities in each category, then the student crosses out the eliminated possibilities until the correct answers become clear. They start off with relatively simple logic problems with three or four variables, then move on to problems that are much more complicated. None of the problems are easy, but the students are given a tool that helps them to begin thinking logically. (2.4, 2.5)

Here are a few other "creative thinking" problems that can get the students actively involved right from the start (2.2, 2.4, 2.5, 2.6, 2.7):

Family: John, his wife and their daughter wish to cross a river. The row boat can only hold 100 kilos. John weighs 80 kilos. His wife and daughter weigh 40 kilos each. How do all three cross the river?

Snail: A snail is at the bottom of a well. The well is thirty feet deep. The snail advances three feet in one day. During the night, the snail slides back two feet. How many days will it take the snail to reach the top of the well?

Kitchen Cups: Suppose you need to measure exactly 1 cup of water. All that you have in your kitchen are two containers. The smaller container hold 3 cups and the larger holds 5 cups. How can you use these two containers to measure exactly 1 cup of water?

Problem of the Day

Each day a new, short problem/brain teaser will be posted somewhere in the room. There are many, many good problems to be found online (try Thinks.com) and in books. There are also all sorts of incentives you could offer to students

who come up with the correct answer: extra credit points, treats, extra privileges (like extra game time!), but believe it or not, the kids get a big kick out of just being the first to figure it out.

Here are a few good ones:

Which of these numbers is the odd-one-out?
43 26 50 37 17 82

The following number has a rather special characteristic. What makes it special?
8,549,176,320

What do the following numbers have in common?
3 7 10 11 12

Peter picked one pepper more than Paul. Pat picked one pepper more than Pam. Peter and Paul picked 10 more peppers than Pat and Pam. Peter, Paul, Pat and Pam picked 60 peppers. How many peppers did Peter pick?

All of these problems require critical thinking skills, reasoning, and logic. (Answers can be found in Appendix B, numbers 5-8).

Activity Center: Board and Card Games, Books

An activity center may sound a little juvenile for middle school, but I've seen quite a few middle school classrooms with them, and they work well. There are going to be times when some students finish their work earlier than the rest of the class, and nothing to do often leads to disruptions.

I've already mentioned some of the games I'll put in my activity center. There are many others that encourage logical reasoning, review basic math facts, and teach students the rewards of perseverance and risk-taking. Here is a short list of some of the games I already have:

Count Across (www.cadaco.com) A simple board game that helps students review their multiplication facts (always needed). Roll the two dice, find the product. The first player to place four chips in a row wins. The game board could be modified so that the students could review fractions, decimals, or subtraction.

Equate (www.ConceptualMathMediacom) Scrabble for math nerds! Players create true equations using number (whole numbers and fractions) and operation tiles. Again, variations are possible: a game can be for single players or teams.

There are advanced tile sets that have negative integers and exponents. There are also boardless activities where all the students are given the same hand in strips of paper tiles, then they rip them apart and come up with as many equations as they can. Equate requires strategic thinking, computing, and creativity.

Farkle Sometimes spelled Farkel, the game is said to have first been played in Iceland in the 14th century by Sir Albert Farkle. In France it is known as Dix Mille (10,000). Each player rolls six dice and then decides which dice to keep for their score (1 is worth 100 points, 5 is worth 50 points, three 3s are worth 300 points, and so on). Unused dice can be rolled again for more points, but if you roll no scoring dice, you have rolled a Farkle and you lose all your points for that turn. It's not a terribly complicated game, but it involves counting and probability, and it is very addictive. I have had ongoing Farkle tournaments in some of my classes, and the kids love it. It's a great motivator; the promise of a game of Farkle can really get the students going.

Set Another very addictive game! Set is a card game that requires quick recognition and deduction. The object of the game is to identify sets of three cards. Each card is unique in its four features: color, shading, symbol, and number. A set consists of three cards on which each feature is either the same on all of the cards, or different on all of the cards. Logic, pattern recognition, and strategy are all used for this game, and students can play alone, with a partner or a group, or as a class (there are Set overheads available). Check out the Set game of the day online (www.setgame.com).

I also have a good selection of math books to put in my activity center, and I'm always on the lookout for more. Besides the previously mentioned Math Curse and the Marilyn Burns books, I also have the complete Sir Cumference series (along with his wife Lady Di of Ameter and his son Radius, Sir Cumference explores the wonderful world of geometry). I have books with math mysteries and brain teasers, and of course the wonderful Greg Tang books. Other books are listed in the bibliography, and Amazon is a great source for really good math books. I always like to encourage my students to read, and these books make math fun and accessible.

Unit Activities

Even though the CMP2 curriculum gives students plenty of interesting investigations and unit projects throughout the year, little "extras" here and there keep the students motivated and on their toes. There are many activities that can help students get ready for a new unit and review what they have already learned.

Again, there are endless resources for games and activities that align with the 7th grade curriculum. The *Mathematics Teaching in the Middle School*

journals are one of my main resources. Another good resource is the Math on Call Teacher's Resource Book. It is actually part of the summer school curriculum, but I rarely have time to use the activities in the summer.

I have listed the five main units that I will be covering in the coming school year, along with some of the goals of the unit and the state standards. I've included a problem or activity for each unit, to be used either before or after the unit has been completed.

Variables and Patterns: (2.3, 2.6, 2.8) Goals include describing patterns of change, constructing tables and graphs to display relations among variables, using algebraic symbols to write rules and equations relating variables, and using tables, graphs, and equations to solve problems.

Activity: How Much Fun? (Math on Call, pp.68-69) The students are given a table showing the admission prices for six different amusement parks (make up your own imaginary parks or do a little research for current prices). Each student will choose a park, then make a table showing the admission prices for 1, 2, 3, 4, *n* visits. They should be able to compare 1-Day admission prices vs. a Season Pass. After completing the table, students should be able to figure out how many visits at the 1-Day rate it will take before they start saving money by buying a Season Pass. The next step is writing an equation for the cost of *n* visits to the park at the 1-Day Admission price, and an equation for the cost of *n* visits at the Season Pass rate. Finally, the students should graph their data showing the two rates. Students could work in groups and figure out the cost for the entire group, and make large colorful graphs to hang up around the room.

Stretching and Shrinking (2.3, 2.9, 2.10) Goals include identifying similar figures by comparing corresponding parts, using scale factors and ratios to describe relationships among the side lengths of similar figures, and predicting the ways that stretching or shrinking a figure affects lengths, angle measures, perimeters, and areas.

Activity: Make a scale drawing of our school and the surrounding grounds. This would definitely be a group project, because our school is huge. Groups could concentrate on just one floor or section. They would have to decide on a scale for their drawings, and figure out the area and perimeters of both the original and the scaled-down version. They could also have the option of designing the perfect classroom. Along with the scale drawings, students should include a table comparing dimensions of the actual places and the drawings, and a report explaining their methods.

Comparing and Scaling (2.1, 2.6, 2.11) Goals include using ratios, fractions,

differences, and percents to make comparison statements; scaling a ratio, rate, or fraction to make a larger or smaller object; and applying proportional reasoning to find the unknown part of two equal ratios.

Activity: Go Fish! This activity is a different version of the capture-recapture problem presented in the CMP2 unit, but instead of using dried beans the students use Goldfish crackers; much tastier! The introduction to the problem explains the premise: the students have been given the task of determining the number of fish in a nearby pond. How do they do it? They can't take all the fish out of the water to count them, and how could they be sure they got them all? To determine the number of animals in a population, scientists often use the *capture-recapture* method. A number of animals are captured, carefully tagged, and returned to their native habitat. Then a second group of animals is captured and counted, and the number of tagged animals is noted. Scientists then use proportions to estimate the number in the entire population. The activity is described below:

Each group needs:

- 1 paper lunch sack - represents the "pond"
- A supply of goldfish crackers - represent the "fish" in the lake
- A supply of pretzel fish crackers - represent the "tagged fish"
- 1 paper cup - represents the "net"
- 1 paper plate

A. Collect the Data

Capture:

1. Each team receives a paper lunch bag with goldfish crackers inside.
2. With the "net," scoop a sample of goldfish out of your "pond" onto the paper plate.
3. Replace your sample of goldfish with pretzel fish. These are your "tagged" fish.
4. Count the number of "tagged" (pretzel) fish and then return them to the bag.
5. There are _____ tagged fish in the entire pond.

Recapture:

6. Shake the bag gently.
7. For the first casting, use your net (cup) to remove a sample of fish. Count the number of "tagged" (pretzel) fish in your sample and record the total in a table.
8. Return all of these fish to the lake (bag) and shake gently to mix them up.

9. Repeat this process until you have gathered information on 10 samples and filled in your table.

B. Analyze the Data
1. To find the AVERAGE number of tagged fish, add up all 10 samples of the tagged fish and divide by 10. Do the same thing to find the AVERAGE number of total fish in your samples. (Using the AVERAGE number with 10 samples is more reliable than using any one sample's data.)
2. Use the proportion below to estimate the total number of fish in your lake:
Average # tagged in samples = # tagged in pond
Average total # in samples Total # fish in pond

ESTIMATED POPULATION:

3. Now count the total number of fish in your lake to determine how close your estimate from the "sampling" is to the actual number of fish in the lake.

ACTUAL POPULATION:

4. How close were you to the actual number of fish?
As a result of this activity, students learn how to gather information about a large population based on a representative sample whose makeup is similar.
1. Where else would scientists use this capture/recapture method?
2. What are some of the factors that could have caused an estimate to be close or not so close to the actual number of fish?

Accentuate the Negative (2.1, 2.2) Goals include comparing and ordering rational numbers, and developing algorithms for adding, subtracting, multiplying, and dividing positive and negative numbers.

Activities: A few brain twisters:

What is the mean of the first 30 terms in the following sequence of numbers -1, 2, -3, 4, -5, 6, -7... (answer #9 in Appendix B)

What is the mean of the first 300 terms in the following sequence
1, -2, 3, -4, 5, -6, 7... (answer #10)

Moving Straight Ahead (2.4, 2.5, 2.8) Goals include constructing tables, graphs, and symbolic equations that express linear relationships, understanding rate of change, slope, and *y*-intercept, and solving linear equations.

Activity: Step Right Up (Math on Call, pp.60-61). The objectives of this activity are to analyze data to determine slope, and to use data from a table to graph a linear equation.

The Empire State Building in New York City was built at the rate of 4½ stories each week. The building has 102 floors. The height from street level to the top of the 102nd floor is 1224 feet. There are 1860 steps.

What is the height of each floor, assuming all floors are the same height?
How many steps are between each floor?
What is the height of each step in inches? (answer #11 in Appendix B)

The height of a step is actually called the *rise* and the depth is called
The tread or *run*. Standard building codes list the required rise of a step
As 8 inches and the required run as 10 inches. Construct and complete a table to determine how many inches you go up and across for each of the first ten steps. Plot the rise and run of the first ten steps on a graph.

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Appendix A

Pennsylvania Department of Education
Academic Standards for Mathematics

Appendix B

Solutions to Problems

1. *Young MacDonald:* 94 chickens

2. *Family:* Mom and daughter cross first. Daughter gets out of boat, mom returns. Mom gets out of boat, dad crosses. Dad gets out and daughter goes back to get mom.

3. *Snail*: 28 days

4. *Kitchen Cups*: Fill the three-cup container with water. Pour it into the five-cup container. Fill the three-cup container again, and fill up the five-cup container. This will leave you with exactly one cup of water in the three-cup container.

5. 43; all the rest are 1 more than a square number.

6. It consists of the digits zero through nine written in alphabetical order.

7. When written out, they only contain the vowel E.

8. 18

9. 0.5 The 30 terms can be grouped into 15 even-odd pairs, each with a sum of 1. For example, -1 + 2 = 1, -3 + 4 = 1, and so on. The sum of the first 30 terms is 1 X 15 = 15/30 = 0.5

10. -0.5 Same reasoning as above.

11. 12 feet, 18 steps, 8 inches