YALE NATIONAL INITIATIVE
to strengthen teaching in public schools®

Curriculum Units by Fellows of the National Initiative
2007 Volume VI: Keeping the Meaning in Mathematics: The Craft of Word Problems

Word Problems in Picture Books: Literature as a Source of Math Word Problems

Curriculum Unit 07.06.04, published September 2007
by Karlene McGowen

Introduction

Reading and Math are the two subjects that are tested most on state standardized tests. That's not to say that other subjects are less important. However, it is common sense to know that you have to read in order to understand the information in textbooks for all subjects. It is also known that other subjects, specifically science, incorporate elements of mathematics. Since math and reading are considered by some to be the foundations of education, it is only fitting that the two should also complement each other. This unit is designed to take the difficult task of solving word problems and pair it with the general knowledge of reading. These two subjects can co-exist and understanding one can be the aid to understanding the other. This unit will look at math word problems through the lens of language arts.

In our middle school, that services grades six to eight, we have found a disconnect between the state standardized scores in Reading and the scores in Math. The students are the same, but for some reason the majority of them do much more poorly on the Math state test than the Reading state test. As a Reading teacher I am interested in this phenomenon. The Math teachers at our school are quite competent and work very hard at educating the students in the math curriculum. It is very disheartening for them and for the rest of the staff to see the results of the Math state test come out so low. There seems to be ample discussion about what these results mean and how we can fix them. However, for the past few years the scores have not increased substantially.

As a Reading teacher looking in, it seems to me that the students are not connecting the math calculations they do in class with the same calculations placed in the form of word problems found on the state test. Perhaps this is where assistance can be given. The Reading and English departments know language. Our middle school has both a Reading department and an English department with the teachers of each subject focusing on different parts of the curriculum. (I'm aware that many schools don't have different departments and that some teachers fill the shoes of both departments. For ease of reading of this unit I will refer to both departments as a unified Language Arts department.) As Language Arts teachers, we study and interpret the meaning of literature for a living. We translate this knowledge to our students. If we combine the knowledge of language from the Language Arts teachers with the knowledge of computations from the Math teachers, we can create a powerful curriculum that benefits all types of learners.

Objective

This curriculum unit will look at math word problems from a language arts point of view. I believe many times students are able to do the math computation but get stumped by the wording in the problem. If I can show them how to read the problem the same way they might read a novel or a non-fiction passage, then I believe they will have greater success at solving the word problem correctly.

The unit is divided into two sections; however these two sections are designed to be used together. The first section involves the use of math picture books. There are many books on the market today that tell a story and use math as the unifying theme. Refer to the Resources list at the end of this document for recommended picture books. I look at these picture story books as one giant word problem. By beginning with these books we can show the students that a word problem is simply a story that involves math. They are very familiar with picture books, so the idea of one that incorporates math is not a big leap for them. The unit will begin by incorporating these stories into the Language Arts curriculum. It seems natural to start in the Language Arts classroom because this is where literature lives and thrives. If the goal is for the Language Arts teachers and the Math teachers to work together, then we have to become somewhat comfortable with the curriculum in each subject. Math teachers will need to use these books in the classroom and read-aloud to the students just like the Language Arts teachers.

The Language Arts teachers would introduce a math picture book into the lesson. It can be done in a variety of ways, the simplest of which is just to perform a read-aloud of the book. This will get the students familiar with the story line. From this point the Language Arts teacher can continue with the math aspect of the lesson or turn it over to the Math teacher. Whoever takes it on will be leading a discussion on various types of word problems that are found within the text itself. This discussion and the subsequent independent or group practice will stem from additional word problems that are created based on the story characters or situation but not necessarily on the actual events of the story. This is further explained with examples in the Picture Books section of this unit. This concludes the overview of the first section.

The second section of the unit involves again the collaboration of efforts between the Language Arts teachers and the Math teachers. We will call it Word Problem(s) of the Week. The students will receive a word problem or several problems on Monday or day one. The students will take the problem(s) to the Reading teacher and they will look at it from a reader's point of view: reading the problem twice, highlighting the important information, crossing out unnecessary information, and underlining the key words that tell the operation to be used. A simple five minute lesson is all that is needed. The teacher shouldn't feel that this plan cuts deeply into their own curriculum. However, the idea of reading a passage and interpreting important information is a reading skill that is part of the curriculum already. So really it is not a deviation from the set curriculum. The next day the students would take the same problem to the English teacher and they would rewrite the problem in their own words. They will also state the question that the problem is asking. On the third day they would take the same paper which now has been looked at twice with the Language Arts teachers and take it to the Math teacher. At this time the Math teacher would help them develop a plan for solving the problem and estimate a reasonable answer for the problem. On the final day the students would take the problem again to the Math teacher and would set up the calculations of the problem, draw a diagram if necessary, solve the problem and finally check the answer to be sure it is reasonable or correct. This plan can be adjusted to fit the schedule of your school, as in it doesn't have to be a four day process. Note however, that each step in that process is relatively quick. When you do give such problems, rather than simply give one problem,

another strategy might be to give a collection of problems, with various settings, and ask students to classify them according to the operation(s) required to solve them. Appendix E at the end of this document indicates the format of a worksheet to be used for this Word Problem(s) of the Week operation.

In merging these two sections, it would be ideal to use the word problems created specifically for the picture books as problems of the week. This can span as much time or as many weeks as necessary. After the picture book word problems are exhausted, word problems pulled from the released state test could be used, especially if they are grouped together by topic. In addition, word problems pertaining to the unit of study currently being practiced could be used as well. It can be adapted to fit all types of word problems from any grade.

In our school we have been exploring ways to help the math standardized test scores increase. I believe this unit will help this increase to happen. An easy way to implement this curriculum unit is to incorporate the reading and writing of the problem into a short warm up lesson for two days a week. It will become part of the daily lessons we do as Language Arts teachers. Eventually the students will no longer need to use this format. After enough practice the students should be able to read, write and solve on their own. It is not necessary to consider that this collaborative and extensive process is required throughout the school year. Hopefully students will begin to read and understand the problems naturally. They will begin to think both linguistically and mathematically.

Vocabulary

In researching volumes and volumes of math word problem strategies for preparation of this unit, I found one particular common theme. Vocabulary is important. It is essential to teach basic vocabulary pertaining to math word problems.

Clearly there is some overlap in the wording for addition and multiplication. That is bound to happen. Usually the problem must be looked at as a whole and a decision of addition or multiplication must be made. There are numerous synonyms for the basic math functions. It is a good idea to know those words. If you don't understand individual words in a word problem, you have little chance of grasping the overall meaning. However, memorizing the following list of words is not a complete solution. The goal is exposure to vocabulary and an awareness of general meaning. Whatever words come up regularly in your classroom should be reviewed with the students so they can understand what is being asked in the problem.

It is important for students to understand the language when reading a math word problem. Many times the simple words of add, subtract, multiply and divide do not even appear in the problem. Instead words such as sum, difference, product, etc. are used instead. This can become confusing to a student if they are unfamiliar with the vocabulary. The first step in helping students to read math word problems more clearly is to equip them with the necessary vocabulary they will likely come across in word problems.

Bluman has provided a short list of synonym vocabulary for help in deciphering words in word problems. The following list is taken from his book. "Use addition when being asked to find: the total, the sum, how many in all, how many altogether" (2005, p. 6); "Use subtraction when you are asked to find: how much more/less, how much larger/smaller, how much more/fewer, the difference, the balance, how much is left, how far

above/below, how much further" (p.7); "Use multiplication when you are being asked to find: the product, the total, how many in all, how many altogether" (p. 8).

Wingard-Nelson also suggests reviewing words that have the same meaning in regards to mathematical function. For addition she uses the same words Bluman uses and also adds the following list: "add, additional, all, and, both, combined, exceeds, gain, greater, in addition to, more than, plus, raise, and together" (Wingard-Nelson, 2004, p. 46). It should be noted however, that some of these are for addition, some for subtraction, and some can be used in calling for either addition or subtraction. It is necessary to note that mathematics vocabulary is not an exact science. For subtraction Wingard-Nelson suggests "changed, comparison, decreased by, dropped, lost, minus, reduced, remain, subtract and take away" (p. 48). It is important to read problems carefully. You can do a service by providing examples of problems, where the language suggests subtraction, but addition is actually called for, and vice versa. Particularly in comparative groups, this could be a powerful lesson. Multiplication synonyms are offered as "at, every, multiply, of, per, rate, times, and twice" (p. 50). Division words were not offered by Bluman, however Wingard-Nelson suggests "average, cut, divided, divisor, each, equal parts, evenly, every, out of, quotient, separate, shared, and split" (p. 52).

It should be noted that phrases and words have different meanings depending on the context of the word problem. The point should be made that these words can be thought of as helpful hints as to what a problem might be about, but that memorizing lists of words is not a substitute for developing the habit of careful reading. Correct interpretation of a problem often depends on a more global understanding of what it says. This presumably is one reason why word problems are difficult. If it were a matter of memorizing key words, the issue would have been settled long ago.

Problem Types

Find the Equation

One type of problem that is abundant on our state standardized test involves providing a scenario in which the student must decide which equation is best to solve the problem. An example is provided.

Mr. Duran handed out 32 sheets of graph paper equally among 8 groups of students. Which equation can be used to find *s*, the number of sheets of paper each group received?

*F. s =32 / 8

G. s =32 - 8

H. s =32 x 8

J. s =32 + 8

Appendix E is found at the end of this document. We will use the appendix format for solving word problems. The first step is to read the problem twice. This is very important for students to remind them not to rush through and just look for the numbers. Next we will decide what the important information is and highlight or

underline that information. We will also eliminate any unnecessary information. In the problem above, it would seem the important information is 32 sheets divided equally among 8. As for unnecessary information, this problem doesn't seem to have any, at least in the sense that there is no distractive information. For this problem we will look at the words and decide what is being asked. We might rewrite the problem to say "Mr. Duran gave eight groups of students an equal share of 32 sheets of graph paper", this would be translated into division. We are dividing or handing out something equally. So we know the equation must involve division. We also need to state the question. This helps students focus on the task at hand. A restatement of the question is "Choose the equation showing that s is the number of sheets of graph paper each group received." We look to see what is being divided and how. 32 sheets of paper handed out or divided equally among 8. So the logical equation would be 32 Ã· 8, which is answer F. Understanding the vocabulary and knowing the synonyms mathematically can be just the boost and assistance students need to help tackle word problems. Although this is a somewhat simple type of problem, the process for solving involves the various steps from each teacher and does not change from problem to problem.

Multiple Step

A multiple step problem involves more than one mathematical calculation and step to decipher the answer. An example follows.

A 10-ounce box of cereal costs $2.98, and a 20-ounce box of the same cereal costs $5.49. Which of these statements will help a shopper decide which box is the better buy?

A. The 10-ounce box is the better buy because it is less expensive per ounce of cereal.

B. The 10-ounce box is the better buy because $2.98 is about $3, and $3 goes into $5.49 about 3 times.

C. The 20-ounce box is the better buy because it is more expensive per ounce of cereal.

*D. The 20-ounce box is the better buy because two of the 10-ounce boxes cost more than one 20-ounce box.

The process will remain the same with the reading step coming first. Read the problem twice. Underline or highlight important information and eliminate any unnecessary information. For this problem the important information would be a 10 oz. box of cereal costs $2.98 and a 20 oz. costs $5.49. The English step of rewriting might be as follows: Cereal comes in two sizes and costs two prices. A 10 oz. costs $2.98 and a 20 oz. costs $5.49. A restatement of the question would be: Choose the statement that factually represents which box is the better buy. The math calculation is multiplication. The number of ounces of the first product multiplies easily by 2 to equal the number of ounces of the second product. The student can see that $2.98 times 2 equals $5.96. This would mean 20 oz cost $5.96 for the first product and an equal amount costs $5.49 for the second product. The next step would be to compare the results to each of the statements to check for validity. Statement A is not true because the 10 oz box is more per ounce, not less. Statement B is estimating on price alone, not volume, and essentially is nonsense. Statement C, although true in the first clause, contradicts itself in the second clause and is therefore false. Statement D is the only true factual statement. Two 10 oz boxes would cost $5.96 for 20 oz and one 20 oz box costs $5.49 for 20 oz. Therefore Statement D is the best answer.

The examples above are just some types of problems to show how this approach works. Any type of problem the student is presented with can be solved by using the three perspectives of Reading, English and Math. After the students begin to see the process, they may not need to use each step as thoroughly as they did when this approach was introduced. Ideally the students will begin to think about math word problems from

these three perspectives naturally and without the formality of the steps. As teachers, we want to encourage students to be independent thinkers. This approach will give them the assistance they need until they are able to be comfortable with solving math word problems independently.

Picture Books

As a Reading teacher, I find every opportunity I can to incorporate picture books, novels and short stories into my instruction. I have found several math related picture books that are perfect for any grade level. Yes, middle school and high school students enjoy picture books just as much as elementary students. For the upper grades, these books can be used as a listening skill practice as well as a math skill practice. For lower grades, a read aloud coupled with demonstrations of problems on the chalkboard will have optimal results for the students. In the end we are talking about reading math. So it is only fitting that we take an actual story and apply our math skills.

Geometry

The following picture books really emphasize geometry and spatial reasoning. They would be great to use as a read-aloud while students are using manipulatives to solve the story.

Sir Cumference and the Sword in the Cone by Cindy Neuschwander

Neuschwander has written a series of books featuring "Sir Cumference". The main character of the series is Sir Cumference who is a knight in King Arthur's court. Other characters include Radius, Vertexand the Lady Di of Ameter. It does not take the reader long to realize that Neuschwander is using a play on words and incorporating geometry into the story. This particular story revolves around Vertex, who begins a quest to solve a riddle from the King. The one who solves the riddle and finds Edgecalibur will become the next king. The clue states,

> Form the solids and find their places. How many edges, points, and faces? The shapes that make two will pass the test, but one that does not must be your quest. Three times as tall as its base is wide, the true King's future lies inside. (Neuschwander, 2003, p. 5)

Surrounding the edge of the parchment are diagrams of shapes. It is later realized these diagrams are solid shapes flattened out. Once this is recognized, Vertex and Radius begin cutting and folding the shapes. The quest now begins. They begin counting faces, points and edges of all the shapes. After many calculations and trial and error, Vertex understood that the cylinder and the cone are the only ones among the given figures that did not produce two when the numbers of faces and vertices were added together and the number of edges was subtracted. Now they know they are looking for an object in the shape of either a cone or a cylinder.

They find many cones under the stones in the path and now see that they must measure them. They are looking for a cone whose length is three times its base. Upon measuring many cones they find the one that is most likely to house Edgecalibur based on knowledge that the sword is approximately 48 inches long. Vertex releases the sword from the cone and takes it to King Arthur. King Arthur is very impressed with his math skills and dubs him Prince Vertex who will rule once Arthur steps down.

This book can be incorporated in many aspects of the curriculum. Just some of the connections are legend, reading, geometry, and problem solving. I maintain that picture books are rarely only for small children. A good picture book can span the grades from first to twelfth and offer a completely different perspective in each grade. This book is just such an example. In reference to word problems, it can be an introduction to a unit on geometric word problems. This book can be regarded as one long word problem, so it is a model example. I believe that using picture books to introduce concepts, on any subject, is always an attention grabber. The illustrations alone capture the attention of students, young and old alike. Specifically with this book, concepts of spatial reasoning, area, measurement, probability and of course geometry can be introduced or reinforced.

If this book interests you then the others in the series might also be of help. *Sir Cumference and the Isle of Immeter* covers the topics of area and perimeter. *Sir Cumference and the First Round Table* explores the topic of taking a rectangular table, which is too long and difficult for everyone seated to see and hear each other, and forming it into various shapes to find the ideal shape for the knights to sit and meet. *Sir Cumference and the Dragon of Pi* covers the number pi through a story in which Sir Cumference drinks a magic potion that turns him into a dragon and only the magic number pi can transform him back. In *Sir Cumference and the Great Knight of Angleland,* Radius uses a circular family medallion to discover angles and ultimately the use of a protractor.

A few word problems for *Sir Cumference and the Sword in the Cone* follow. More can be found in Appendix A.

The path of stones in the courtyard created a rectangular space with an area of 925 square feet. What is the width of the space if the length is 37 feet?

*A. 25 ft

B. 74 ft

C. 425.5 ft

D. 462.5 ft

King Arthur designed a flower garden in the courtyard in the shape of a square. He plans to build a walkway through the garden diagonally from one corner to the other. If the length of each side of the garden is 12 feet, which is closest to the length of the walkway?

A. 36 ft

B. 24 ft

*C. 17 ft

D. 13 ft

Vertex made a scale drawing of his room in the castle. The actual room has a width of 16 feet and a length of 24 feet. His drawing has a length of 3 inches. What is the width, in inches, of the scale drawing of the room? (2 in.)

Spaghetti and Meatballs for All! By Marilyn Burns

I think this book covers a lot of thinking about math in a fun story. The premise is that Mrs. and Mr. Comfort are throwing a dinner party for their family. They find out there will be 32 people. They arrange 8 tables with 4 chairs each. The problem arises when the families begin to arrive and want to sit together. They begin pushing the tables together to make one big table. As more and more guests arrive, the families continue to rearrange the tables so everyone can sit together. Of course throughout this time Mrs. Comfort is getting very distraught because she knows that if the tables are pushed together there will not be a seat for everyone. The story continues with more arrangements of the tables until eventually the tables start being pulled apart as the rest of the family arrives. In the end the tables again end up as 8 tables with 4 chairs each, just as Mrs. Comfort had originally set.

There is spatial reasoning involved because 2 tables of 4 will seat 8, however if those 2 tables are pushed together then suddenly they only seat 6. The spacing problems continue as more tables are pushed together and fewer seats become available. One listening activity for this book is to provide students with manipulatives of the tables. This can even be simple squares of paper. As the story is being read, either individually or in groups, the students can arrange the tables to match what is happening in the story. This can help the students visualize area and perimeter. It would be pertinent to note that the combined area of the tables is constant, since the number of tables is constant, but the perimeter, which is proportional to the number of free edges, changes from configuration to configuration.

There are numerous ways to use this book as a supplement to the math curriculum. Substituting and interchanging the words chair, seat and perimeter would help the students understand units of measurement. How many seats will there be in a row of 5 tables that are set end-to-end? The students can also be asked what other options the Comfort family had in regards to seating. This can include getting more tables and arranging in various ways. What about an octagonal or hexagonal table? This configuration would be a bit more difficult than square tables. How could this have worked into the plan? This book can be used as a whole class read-aloud or be put at a station for individual or small group work. The importance is that the students are putting together the words of a story with the calculations of math. This can help them when they are asked to solve individual word problems.

Following are a sample of word problems for this book. More word problems can be found in Appendix B.

Which of the following is NOT a valid formula for the perimeter of a square table with side length s?

F. $s + s + s + s$

G. $2s + 2s$

H. $4s$

*J. $s \times s$

Which expression can be used to solve the problem below? The Comfort's considered throwing their party at a hotel. To cater a luncheon, a hotel charges $50 per hour for use of a dining room plus $24.50 per person. What is the total cost for a 2-hour luncheon for 45 people?

F. 2 x 50 + 24.50 + 45

*G. 2 x 50 + 24.50 x 45

H. 2 x 24.50 + 50 x 45

J. 2 x 45 + 50 x 24.50

Exponential Growth

The following picture books deal with the concept of exponential growth. American Heritage dictionary defines this term as, "Growth of a system in which the amount being added to the system is proportional to the amount already present: the bigger the system is, the greater the increase." There are vast possibilities with this type of math. Many students don't realize how quickly numbers can increase if done exponentially, even in a short period of sessions. These two books incorporate the concept of exponential notation into a storyline that is easy to understand and thereby help to make the concept more concrete. Upon reading the two books you will see that although they both incorporate exponential growth, the results of the stories are different. In Demi's book the growth is unfettered, adding grains each time and not removing any within the process. At the start of Anno's story the main character removes one seed each time a doubling growth is experienced. In addition there are other removals of various amounts as the story continues. So in this regard, the growth is not purely exponential in that every time growth occurs, so does removal of a seed. However, each story does teach exponential growth approaching the total from a different path.

Anno's Magic Seeds by Mitsumasa Anno

One day Jack is strolling along and comes across a wizard. The wizard gives Jack two golden seeds and explains that the seeds are magic. His instructions are, "Bake 1 seed in the oven until it is red and then eat it. You will not be hungry again for a whole year. Bury the other seed in the ground now and care for it well. I promise you it will grow and give you 2 more magic seeds in the fall" (Anno, 1995, p.3). Jack does as he is instructed and continues the cycle of eating one and burying one for several years. One day he realizes that this cycle can just go on and on forever always breaking even. He decides to bury both seeds and gets through the winter by eating something else. In the spring two sprouts came up producing four seeds. Jack baked and ate one seed and planted the other three. He continues to do this for six years, each year planting more and more seeds. In that year he meets a girl named Alice and the two of them each eat a seed and bury the rest. The next year Alice and Jack marry and give 2 magic seeds to each of their 5 wedding guests. That same year Jack and Alice store 16 seeds in a storehouse and bury the rest. They eventually begin selling the magic seeds at the town market, always planting more than they sold. In the tenth year a hurricane comes and the land floods. Jack is able to tie the house to a tree and he scoops up one small bag of seeds. When the storm was over his fields were empty and bare. However, Jack sees that he was able to save 10 seeds which are enough for Jack, Alice and their baby to eat and the rest were planted to start their new life.

A sample of word problems follows. More can be found in Appendix C.

A seed, given a favorable growth medium, doubles in number every 6.5 hours. Given that there were approximately 100 seeds to start with, how many seeds will there be in a day and a half? (approx. 4,648)

Jack is researching a newly-discovered species of seed. At time $t = 0$ hours, he puts one hundred seeds into what he has determined to be a favorable growth medium. Six hours later, he measures 450 seeds. Assuming exponential growth, what is the growth constant "k" for the seeds? (Round k to two decimal places.) (The growth constant is 0.25/hour)

One Grain of Rice: A Mathematical Folktale by Demi

The premise of the story is that an Indian raja made all the peasants give him most of their rice. They were able to keep just enough to get by. In the meantime he stored all of this rice in a royal storehouse for himself. Although he promises them that everyone would have rice to eat even in times of famine, the raja did not keep his promise. When there was a drought one year the peasants begged the raja to give them some of the rice that was stored in the royal storehouse. He refused saying, "No! How do I know how long the famine may last? I must have the rice for myself. Promise or no promise, a raja must not go hungry!" (Demi, 1997, p.6). One day a village girl name Rani saw that a bit of rice was falling from an elephant carrying a basket on his way to the palace. The girl carefully picked up each grain and filled her skirt. She took the grain to the raja to return it. As an acknowledgment of her good deed the raja told Rani she could ask for anything and receive it. The only thing she asked for is to give her a single grain of rice and then each day for thirty days double the amount given the day before. The raja thinks this is a meager reward but did as she wished. As the days went on it is not long before the raja realizes the intelligence of the girl. On the thirtieth day she is presented with 523,870,912 grains. Adding to the total grains from each of the previous 29 days, Rani ends up with a total of 1,073,741,823 grains of rice. Rani shared it will all the hungry people of the village and left a basket of rice for the raja. She told him to only take what grain he needed from now on. The raja promised to do so and, "for the rest of his days, the raja was truly wise and fair, as a raja should be" (Demi, 1997, p.30).

The following word problems can be implemented as an additional activity with *One Grain of Rice*. It is up to you how and when you implement them into the lesson, but it is important to show how the book is one big word problem and there are smaller word problems that can come from the story that take a turn different from the original story line. Additional word problems for this book are found in Appendix C.

Four handfuls of rice equal two thousand and forty-eight grains. How many grains are in one handful? (512) How many grains are in 6 handfuls? (3,072) How many handfuls would it take to hold 6,144 grains? (12)

In looking at patterns of the exponential growth table for this story we can see that the numbers can be found through different questions. For example: What is the product of the number or grains Rani got on the 5th day with the number she got on the 10th day? (32,768). We can see that this number equals the number of grains she got on the 15th day. How many grains of rice did Rani get on the 20th day? (1,048,576). What is the product of the number or grains of rice Rani got on the 10th day with itself? (Again, 1,048,576). A discussion of the reason for the equalities can generate a higher order level thinking skill for students.

The book has a chart in the back showing the progression of grains from day one to day thirty. This chart can be copied and certain days can be eliminated. The students can then calculate the correct number that would go in that day. In addition, the students could also calculate the amount of grains for days beyond thirty.

Money

Money seems to be a topic that most students relate to. It is one of the few topics that students have an interaction with outside of the classroom. Many math teachers say that using money to teach decimals really makes the subject concrete for most students. Money can be used to teach addition, subtraction, comparison and percent when dealing with interest rates. The following story uses money as the basis for the storyline. Although the story is somewhat elementary for middle school, if used with the right questions and challenges, students will embrace it more as a word problem challenge, than a story to be comprehended.

Pigs Will Be Pigs: Fun With Math and Money by Amy Axelrod

The story tells of a pig family who has nothing left to eat in the refrigerator. They decide to go out to eat but

then realize that among them they only have one dollar. The family decides to search the house for money in order to come up with enough for the four of them to dine at a restaurant. The story gives us an account of the coins and bills each pig finds. In this way the story lends itself to listening skills practice because the students will have to keep track of all the money that is found and add up the coins to find total amounts. This book incorporates the theme of money with the math skill of addition. There is also a comparison and evaluation when the pigs go to a restaurant and have to decide what they can order based on the amount of money they have.

Here are some word problems that can be used as supplement to the story. Some questions include the menu that is part of the story. A copy of the menu should be provided to the students along with the word problem questions.

The piglets found six dimes, one dollar bill and two hundred pennies. Mrs. Pig found two nickels, five pennies, one quarter and a five-dollar bill. How much did they collect together? Who collected more money? ($9, Mrs. Pig) What is the correct order of steps to complete the previous two questions? (Add up piglets' money, add up Mrs. Pig's money, add the totals together, look at the figures and decide which is larger)

Mr. Pig found $23, Mrs. Pig found $6.90, the piglets found $4.77. What percent of the total did each pig find? Round to the tenths place. (Mr. Pig 66.3%, Mrs. Pig 19.9%, piglets 13.8%)

Write an equation(s) that represents Mr. and Mrs. Pig receiving 2/3 of the total money and the piglets receiving 1/3 of the total amount found of $34.67. Solve the equation. (22.88, 11.44)

Conclusion

Utilizing a combination of reading and math can really help struggling math students. It can also help math students who have mastered math word problems see them from a different point of view. As teachers, we all know that students tend to favor one over the other. With the help of this unit, students can hopefully see the connection between both. As teachers, we should always look for ways to collaborate across subject areas. The more we can connect to each subject, the more the students will understand and appreciate the necessities of all subjects.

Lesson Plans

Lesson Plan 1

Objective: Students will be introduced to Word Problem(s) of the Week and Vocabulary

Materials: Word Problem(s) of the Week handout, Vocabulary list

Activity: To begin the routine of Word Problem(s) of the Week, students must understand the concept behind the project. The Math teacher should introduce the method and explain that it is a collaborative effort among

the Math, Reading and English teachers. The Math teacher will give each student a Word Problem(s) of the Week handout and explain the process. After all explanation and questions have been answered, the teacher will begin with the vocabulary lesson. As stated previously, all words should not be introduced at the same time. A general list of common words should be used and explained. As the lessons continue, more words can be added to the list as they arise. The initial vocabulary lesson is simply an overview and also meant to help the student become aware of the math words and how they are used. It is very possible that when you start this unit you have already done math vocabulary, in which case a brand new lesson is not necessary.

The remaining lesson plans focus specifically on types of math picture books. The categories of geometry, exponential growth, and money are highlighted. Additional or alternative picture books and topics may be inserted to fit the needs of your students.

Lesson Plan 2

Objective: Students will be introduced to geometry math picture books

Materials: Geometry Math Picture Book (refer to references), Word Problem(s) of the Week handout

Activity: This lesson will repeat itself for each new picture book introduced. A brief discussion of geometry should be done by the Math teacher. Using the geometry picture book can either be a supplemental introduction, or a review. The picture book should be read by the Reading teacher. She may choose any read-aloud method desired, such as reading all the way through, stopping for questions, or stopping for explanation. She should inform the students that the next few Problem(s) of the week will come from this book. After the book is read, the first problem will be reviewed on the handout. This activity can be done the next day or the next class meeting. When the problem is reviewed, the Reading teacher will help the students decide what the important information is and then highlight or underline that information. The problem will next be taken to the English teacher. The teacher will help the students rewrite the problem in their own words and also restate the question. Finally, the problem will be taken to the Math teacher where the set-up, solving, and checking will take place.

It would be ideal if each teacher had a copy of the book to refer to while solving these problems, though it is not mandatory.

Depending on the difficulty of the word problem, several problems can be presented for each week. Each problem would need a separate handout. Time could be devoted to review two or three problems at a time if they are relatively simple. The problems, however, should be similar. In other words the problems should come from the same book. Or if you are no longer using books, then the problems should be of the same type i.e. multiplication, division, geometry, etc.

Lesson Plan 3

Objective: Students will be introduced to exponential growth math picture books

Materials: Exponential Growth Math Picture Book (refer to references), Word Problem(s) of the Week handout

Activities: A general introduction to exponential growth should occur before the introduction of the picture book. The format of the lesson will be the same as the prior lesson. The book will be read by the Reading teacher. When the word problems are introduced the Reading teacher will assist in highlighting important information in the word problem. The English teacher will assist in rewriting the problem and restating the

question. The Math teacher will assist in setting up the problem, solving and checking. Again, if the problem is relatively simple, then several problems can be grouped together and done as problems of the week. Each problem should relate to the picture book

Lesson Plan 4

Objective: Students will be introduced to money math picture books

Materials: Money Math Picture Book (refer to references), Word Problem(s) of the Week handout

Activities: A general introduction to money and decimals should occur before the picture book is introduced. The same procedure should occur as the previous lesson plans. The book will be read by the Reading teacher. When the word problems are introduced the Reading teacher will assist in highlighting important information in the word problem. The English teacher will assist in rewriting the problem and restating the question. The Math teacher will assist in setting up the problem, solving and checking. Again, if the problem is relatively simple, then several problems can be grouped together and done as problems of the week. Each problem should relate to the picture book.

An appendix of word problems for each book has been provided in this document. In addition, word problems were presented in the document and discussed. Any word problem you wish to use is perfectly acceptable for this curriculum unit. Adapt the unit and the lesson plans to fit your needs.

Resources

Student Resources

Anno, Mitsumasa. (1995). *Anno's Magic Seeds.* New York: Philomel Books.

A wizard gives Jack two golden seeds and directs him to eat one and bury the other. He promises it will grow and give 2 more magic seeds in the fall. Jack does as he is told, and the cycle repeats for a number of years, until Jack decides to bury both seeds. The tale of exponential growth is discovered as Jack buries more and more seeds. The math tale becomes even more rigorous as Jack marries, has a child, begins to store some seeds and sell others... until a hurricane wipes out the crops and Jack must begin all over again.

Axelrod. Amy. (1994). *Pigs will be Pigs: Fun with Math and Money.* New York: Simon

and Schuster Books for Young Readers.

After gobbling up all the groceries, Mr. Pig, Mrs. Pig and their two piglets are hungry again, but the Piggy bank is empty. The Pigs turn their house upside down looking for spare change so that they can go out to dinner. Readers are meant to keep a tally of the dimes and nickels the Pigs locate. Finally, after finding a grand total of $34.67, the Pigs spend almost all of it at a Mexican restaurant and readers can calculate the tab by reading a menu.

Burns, Marilyn. (1997). *Spaghetti and Meatballs for All: A Mathematical Story.* New

York: Scholastic.

Mrs. and Mr. Comfort are throwing a dinner party for their family. They find out there will be 32 people. They arrange 8 tables with 4 chairs each. The problem arises when the families begin to arrive and want to sit together. They begin pushing the tables together to make one big table. As more and more guests arrive, the families continue to rearrange the tables so everyone can sit together. Of course throughout this time Mrs. Comfort is getting very distraught because she knows that if the tables are pushed together there will not be a seat for everyone. The story continues with more arrangements of the tables until eventually the tables start being pulled apart as the rest of the family arrives. In the end the tables again end up as 8 tables with 4 chairs each, just as Mrs. Comfort had originally set.

Demi. (1997). *One Grain of Rice: A Mathematical Folktale.* New York: Scholastic.

It's the story of Rani, a clever girl who outsmarts a very selfish raja and saves her village. When offered a reward for a good deed, she asks only for one grain of rice, doubled each day for 30 days. That's lots of rice: enough to feed a village for a good long time—and to teach a greedy raja a lesson.

Lewis, J. Patrick. (2002). *Arithmetickle: An Even Number of Odd Riddle-Rhymes.* San

Diego: Harcourt.

This book offers a variety of clever math riddles with titles like "Finger Play" (which teaches a nifty trick for multiplying by nine) and "Your Average Cow," which asks kids to compare bovine and human life expectancies. Answers appear (upside-down) below each entry

Neuschwander, Cindy. (1999). *Sir Cumference and the Dragon of Pi.* Watertown,

MA: Charlesbridge.

Covers the number pi through a story in which Sir Cumference drinks a magic potion that turns him into a dragon and only the magic number pi can transform him back.

_____(1997). *Sir Cumference and the First Round Table.* Watertown,

MA: Charlesbridge.

Explores the topic of taking a rectangular table, which is too long and difficult for everyone seated to see and hear each other, and forming it into various shapes to find the ideal shape for the knights to sit and meet.

_____(2001). *Sir Cumference and the Great Knight of Angleland.* Watertown,

MA: Charlesbridge.

Sir Cumference's son, Radius, in a quest to earn his knighthood by rescuing a king, uses a circular family medallion to discover angles and ultimately the use of a protractor.. The circular medallion (a protractor) given to Radius by his father and his mother, Lady Di of Ameter, aid him in examining every angle along the way. A circular medallion comes with the book.

_____(2006). *Sir Cumference and the Isle of Immeter.* Watertown,

MA: Charlesbridge.

Young Per loves to play games. When she visits her uncle Sir Cumference and her aunt Lady Di of Ameter, they teach her a new game involving inners and edges. To solve it, the youngsters must travel to the Isle of Immeter and use a series of geometric

formulas to tame the sea serpent and bring peace to the area. This story covers the topics of area and perimeter.

_____(2003). *Sir Cumference and the Sword in the Cone.* Watertown,

MA: Charlesbridge.

Simulates the story of King Arthur and implements elements of geometry to solve the riddle.

Teacher Resources

Bluman, Allan G. (2005). *Math Word Problems Demystified.* New York: McGraw-Hill.

This easy to follow book teaches proven methods for analyzing and solving any type of math word problem. Strategies are given along with many examples and step by step solving methods. This is one in the "Demystified" series. Others include "Algebra Demystified", "Geometry Demystified", and "Calculus Demystified".

exponential growth. (n.d.). *The American HeritageÂ® New Dictionary of Cultural*

Literacy, Third Edition. Retrieved July 07, 2007, from Dictionary.com website:

http://dictionary.reference.com/ browse/exponential growth

Lampert, Magdalene. (2001). *Teaching Problems and the Problems of Teaching.* New

Haven: Yale University Press.

In this book an experienced classroom teacher and noted researcher on teaching takes us into her fifth grade math class through the course of a year. Magdalene Lampert shows how classroom dynamics—the complex relationship of teacher, student, and content—are critical in the process of bringing each student to a deeper understanding of mathematics, or any other subject.

Pullman, Phyllis. (2001). *How to Solve Word Problems in Arithmetic.* New York:

McGraw-Hill.

Formatted for 5th through 8th grade-level arithmetic, helps students by emphasizing the mechanics and grammar of problem-solving, and focusing on problems involving arithmetic skills, area, percent, basic geometry, measurement, and statistics. This is also in a series. Other titles include, "How to Solve Word Problems in Algebra", "How...in Geometry", and "How...in Calculus".

SparkNotes. (2006). Common Word Problems. Retrieved July 26, 2007 from

http://www.sparknotes.com/testprep/ books/sat2/math2c/chapter5section6.rhtml.

This site provides a variety of word problems for solving.

Stapel, Elizabeth. (2007). Purplemath. Exponential Word Problems. Retrieved July 26,

2007 from http://www.purplemath.com/modules/ expoprob2.htm.

This website has a few exponential word problems that helped me create problems for this type.

Word Problems For Kids. (1999). Retrieved on July 26, 2007 from

http://www.stfx.ca/special/mathproblems/ welcome.html.

Word problems are categorized from grades 5 to 12. All types of word problems as well as answer are available for use.

Wingard-Nelson, Rebecca. (2004). *Problem Solving and Word Problems.* Berkeley

Heights, NJ: Enslow Publishers.

This book provides an overview of basic problem-solving strategies and skills, including solving algebraic expressions and equations and different kinds of word problems.

Appendix A

Sir Cumference and the Sword in the Cone

1. King Arthur is considering renting an apartment for his son Radius that has 325 square feet of space. The rent is $1,300 per month. A larger apartment in the same building is available for $2,100 per month at the same rate per square foot as the smaller apartment. What is the area of the larger apartment?

F 525 ft^2

G 1,625 ft^2

H 3,400 ft^2

J 840 ft^2

2. Lady Di of Ameter is constructing a 28-by-40-foot area for a concrete slab for an outdoor patio. If the concrete company charges $120.00 per cubic yard of concrete, what other information is needed in order to find *c*, the cost of the concrete slab?

F The area of the slab

G The thickness of the slab

H The perimeter of the slab

J The price per cubic foot of concrete

3. Radius' room, a rectangle *STUV* is similar to Vertex's room, a rectangle *LMNO*. The measurement of TU is 12 and the measurement of MN is 6. If the area of rectangle *STUV* is 72 square units, what is the area of rectangle *LMNO*?

F 36 $units^2$

G 24 $units^2$

H 18 units^2

J 12 units^2

4. Vertex shipped a birthday gift to his grandmother in a cubical box. Each side of the box measured 2.5 feet. Which is closest to the surface area of the box?

A 10 square feet

B 20 square feet

C 30 square feet

D 40 square feet

5. Vertex drew a circle with a radius of 20 inches and another circle with a radius of 10 inches. What is the approximate difference between the areas of the 2 circles?

F 300 in.^{2}

G 600 in.^{2}

H 900 in.^{2}

J 1,200 in.^{2}

6. Sir Cumference is building a toy chest. The height is 2 feet, the length is 5 feet and the width is 4 feet. What is the volume of the toy box in cubic feet?

7. King Arthur draws the following 4 figures. Figure I, a rectangle, has width 6 cm and length 10cm. Figure II, a triangle, has base 10 cm and height 12.5 cm. Figure III, a trapezoid, has height 10 cm, short width 5 cm, and long width 7 cm. Figure IV, a circle, has a diameter of 10 cm. Which 2 figures have the same area?

A Figure I and Figure II

B Figure I and Figure III

C Figure II and Figure III

D Figure II and Figure IV

8. Vertex is making props to help solve the puzzle. He needs to make a large circular wooden figure that measures about 6 feet in circumference. Which equation can he use to find *r*, the radius of the figure?

A ***r***= 6/?

B ***r***= 12/?

C*r* = 6/2?

D ***r***= 12/2?

9. King Arthur has drawn a rectangle as a clue to the puzzle. The length of the rectangle is four times its width and the perimeter of the rectangle is 80 inches. Find the measures of its length and width.

10. Another clue has emerged for Radius to solve. The base of a triangle is 6 inches larger than its height. If the area of the triangle is 8 square inches, find the base and height of the triangle.

Appendix A Answer Key

1. F

2. G

3. H

4. D

5. H

6. 40 ft3

7. B

8. C

9. length = 32 in., width = 8 in.

10. base = 8 in., height = 2 in.

Appendix B

Spaghetti and Meatballs for All by Marilyn Burns

1. At the Comfort family house there are a total of 6 tables in the dining room. Three of the tables will seat 4 people each. Three of the tables will seat 8 people each. What is the maximum number of people who can sit at the tables in the dining room?

F 40

G 12

H 22

J 36

2. The perimeter of three tables pushed together is 720 inches and the length is 3 times the width. Find its dimensions.

3. Five tables are in a row. The perimeter of the rectangle is 780 inches. If the length is 10 inches less than twice the width, find its dimensions.

4. Mr. Comfort put a stone pathway in the backyard and planted grass that covered the rest of the yard. The rectangular backyard is 100 feet by 80 feet, and the stone pathway is 13 feet by 8 feet. What is the area of the backyard that is planted with grass?

F 402 sq ft

G 7,896 sq ft

H 8,000 sq ft

J 8,104 sq ft

5. If the cost of renting a table is a basic fee of $5 plus an additional $2.50 for each hour that the table is rented, which equation can be used to find *c*, the cost in dollars of the rental for *h* hours?

A $c = 2.5h + 5$

B $c = 5h + 2.5$

C $c = 2.5(h + 5)$

D $c = 5(h + 2.5)$

6. Mrs. Comfort wants to make her yard look nice for the gathering. She has $25.00 to spend on seeds for her flower garden. Marigold seeds cost $1.50 per package, and zinnia seeds cost $1.25 per package, tax included. If Mrs. Comfort buys 10 packages of marigold seeds, how can she determine how much money she has left to spend on zinnia seeds?

A Add $1.50 and $1.25

B Subtract the product of 10 and $1.50 from $25.00

C Multiply $1.25 and 10

D Divide 10 by $1.25

7. The area of a rectangle of tables is 60 square inches. The length is 4 inches longer than the width. Find its dimensions.

8. If the length and the width of a rectangle of tables are increased by two inches, the area of the rectangle of tables is 120 square inches. If the length and the width of a rectangle of tables are decreased by two inches, the area of the rectangle of tables is 48 square inches. Find the length of the rectangle.

A. 6 inches

B. 7 inches

C. 10 inches

D. 12 inches

9. Mr. Comfort plants two square plots for his garden in the backyard. The total of the areas of both plots is 225 square feet. If the side of one plot is 3 feet longer than the side of the other one, find the length of the side of the smaller plot.

A. 8 feet

B. 9 feet

C. 12 feet

D. 14 feet

10. Mrs. Comfort must buy paper plates and plastic forks for the family reunion. Plates are sold in packages of 8 and forks in packages of 12. What is the least number of packages of plates and packages of forks that Mrs. Comfort can buy to have an equal number of plates and forks?

A 2 packages of plates and 3 packages of forks

B 3 packages of plates and 2 packages of forks

C 4 packages of plates and 6 packages of forks

D 6 packages of plates and 4 packages of forks

Appendix B Answer Key

1. J

2. length = 108 in., width = 36 in.

3. length = 70 in., width = 40 in.

4. G

5. A

6. B

7. length = 10 in., width = 6 in.

8. C

9. B

10. B

Appendix C

Anno's Magic Seeds by Mitsumasa Anno

One Grain of Rice: A Mathematical Folktale by Demi

1. A group of planted seeds grows by 35% every hour. If Anno begins with 100 seeds, how many are there after 6 hours?

2. In his first year Jack produced 2 seeds. In his second year he produced three-times as many seeds. In his third year he produced 5 times as many seeds as the first year. How many seeds will Jack have produced in his first 3 years? If he sells the seeds for $200.00 each, how much will he have made?

3. From his earnings of seed sales, Jack saved $2.00 on January 1, $4.00 on February 1, $8.00 on March 1, $16.00 on April 1, and so on. How much money would he save in one year?

4. Jack sold 100 seeds in five days. Each day he sold 6 more than the day before. How many seeds did he sell on the first day?

5. The amount of money Rani received for the grains of rice she sold was $1,000. On January 1, 2002 she put the money in an interest yielding savings account. It grows at a constant rate of 2% per year. In what year does the amount first exceed $1,500?

6. Rani passed around a basket of cooked grains of rice to the girls at her party. Before the party she ate 5 grains and gave a friend 3. Eight girls arrived at the party. The first girl took a grain, the second girl took 3 grains, the third girl took 5 grains and so on, each girl taking two more than the girl before. After the last girl took her grains, the basket was empty. How many grains were in the basket at the beginning?

7. One bowl holds four thousand ninety-six grains of rice. How many grains would it take to fill 14 bowls? If there are 93,814 grains, how many bowls will it take to hold them all?

8. One deer can carry one basket of rice containing 8,388,608 grains. One Brahma bull can carry two baskets of rice containing 2,097,152 total grains. Which team of animals can carry more grains: 4 deer or 15 Brahma bulls? How many more grains can that animal carry? How many more bulls are needed to carry the same amount as four deer?

9. How many grains of rice did Rani get on the 5th day? How many grains of rice did she get on the 10th day? How many grains of rice did Rani get on the 15th day?

10. What if, on the 10th day some rice fell out of the bag before it was delivered to Rani, and she only got 500 grains, and then this amount kept getting doubled. How many grains of rice would she get on the 15th day? On the 20th day? Do you have to compute this out, or is there some way you could have predicted the answer more easily?

Appendix C Answer Key

1. 605

2. 18 seeds; $3600

3. $8,190

4. 8

5. halfway through the year 2022

6. 72

7. 57,344; 23

8. deer team = 33,554,432 bull team = 31,457,280; 2,097,152; 1; (Again, we see a pattern with the numbers. The amount of difference with these two teams is the same amount as one Brahma bull can carry.)

9. 512; 1,024; 32,768

10. 16,000; 512,000; answers will vary

Appendix D

Pigs Will Be Pigs by Amy Axelrod

1. The Pig family found $34.67. They wanted to use the money to buy a meal and to put gas in the car. They wanted to save the money they had left. Which is the correct order of steps to find the amount of money the Pig family would have left to save?

Step K: Find the sum of the costs of the meal and the gas.

Step L: Find the difference between $34.67 and the sum of the costs of the meal and the gas.

Step M: Identify the cost of the meal and the cost of the gas.

A L, K, M

B M, K, L

C L, M, K

D K, L, M

2. The piglets attended a basketball camp for two weeks. The parents paid $50.00, which was 1/3 the cost of attending the camp. The piglets had saved money to pay the rest of the cost. Which equation can be used to find *c*, the entire cost of attending the camp?

F c = 50 - 2/3

G c = 50 - 3

H c = 1 / (50 - 3)

J c =50/3

3. Four pigs attended a football game and agreed to share the cost evenly. The total cost of the tickets was $51, the taxi ride to and from the game was $24, and snacks and drinks were $30. Which equation can be used to find *c*, the amount each pig should have paid?

F*c* = (51 + 24 + 30) x 4

G *c* = (51 + 24 + 30) Ã· 4

H *c* = 51 + 24 + 30 + 4

J *c* = 51 + 24 + 30 - 4

4. The Pig family is ordering the food from the restaurant menu. Each pig will need a drink that costs $1.00 and a meal that costs $4.99. If ***x***represents the number of pigs, which equation can be used to find ***y***, the amount in dollars spent by the Pig family?

A *y*= 4.99***x***+ 1

B *y*= 5.99***x***

C y = ***x***+ 5.99

D *y*= ***x***+ 4.99

5. The pigs have $34.67 to spend in the restaurant. Do they have enough money for a stuffed jalapenos appetizer, Mrs. Pig to order cheese enchiladas, Mr. Pig to order bean burritos, each piglet to order chimichangas, each pig to order tea, two orders of deep-fried ice cream and one order of flan? How much more money do they need or how much money is left?

6. The pigs have $34.67 total. Assuming that each pig is given and equal share, create a menu order where each pig gets at least two items (drinks count as items) and each item is used only once.

7. Mr. Pig found $22 more than Mrs. Pig. Together they found $34.00. How much did each pig find?

8. The menu states that all menu prices include tax and tip. Using an 8.25% tax rate and a 15% tip rate, calculate the individual totals for food, tax, and tip based on a total bill of $31.74. (*Hint: tax is added before tip)*

9. There are 30 items on the menu. If 20% of the items are more than $4, how many items are more than $4?

10. A waiter makes 15% tip on the total bill for each of his tables. Over two weeks, his tips totaled $1,125. Find the total amount billed to all his tables.

Appendix D Answer Key

1. B

2. G

3. G

4. B

5. Yes, $4.21 remaining

6. answers will vary

7. Mr. Pig found $28, Mrs. Pig found $6

8. food = $25.50, tax = $2.10, tip = $4.14

9. 6

10. $7,500

Appendix E

Word Problem(s) of the Week

Reading

Read the word problem twice. Highlight the important words. Eliminate any unnecessary information.

English

Rewrite the problem in your own words. Organize the information into logical sequence. State the question. (What is the problem is asking you?)

_____

_____

_____

_____

_____

Math

Set up the problem for solving. Draw a diagram for visualization. Solve and check.