

# THE WILLIAM AND FLORA HEWLETT FOUNDATION

## *MIRANDA'S MATH* USER SCENARIO

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**THE WILLIAM AND FLORA HEWLETT FOUNDATION**  
**MIRANDA'S MATH**  
**USER SCENARIO**

The following user scenario is based on actual events. The scenario illustrates how a family and teacher seek to solve a learning problem using traditional resources, contrasted with a new offering, web-based software with high learning value and high play value, developed with funding from the Hewlett Foundation. The scenario involves a first grader we'll call Gabe, who is getting behind in math. This scenario zooms in on a trouble spot for young learners, place value concepts. Many other concepts could be addressed in reading or other subject areas. Place value provides an example of one important set of "hard" concepts taught in school.

**A FIRST GRADER CHALLENGED BY MATH**

A first grade boy named Gabe hasn't thought much about the number ten being much different from the number nine. To him, it's just the number that comes after 9 in a very familiar series. The administrators at Gabe's school are concerned about testing associated with the "No Child Left Behind" initiative, so are pressuring teachers to follow national standards and state frameworks, which in this state call for teaching "addition with carrying" and "subtraction with borrowing" before teaching place value. Gabe memorizes the procedure for adding numbers like " $18 + 5 = \underline{\quad}$ " and subtracting " $25 - 6 = \underline{\quad}$ ," but doesn't know why this procedure works. Gabe's finding math hard. His scores on homework are not great and his family is getting concerned.

**PARENT AWARE OF HIGH STAKES TESTS**

Gabe's mother is also aware of the high stakes tests he'll face in a couple years and she doesn't want him to get behind at such a young age. She purchases McGraw-Hill's<sup>1</sup> book on standardized test-taking skills in first grade. (See *Figure 1. Sample Test Preparation Items*). She notices that Gabe has no idea how to answer the items about place value on the practice test:

Which number has 7 tens and 3 ones?  
10   7103   73   731

Which one shows the expanded numeral for two - hundred and forty-six?  
 $200 + 40 + 6$     $200 + 46$     $246 + 100$     $2 + 100 + 46$

How many tens and ones are there in ninety-five?  
9 tens and 5 ones   5 tens and 9 ones   90 tens and 5 ones   95 tens and 5 ones

Figure 1: Sample Test Preparation Items (McGraw-Hill)

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<sup>1</sup> Foreman, Dale I., S. Alan Cohen, Jerome D. Kaplan et al. *Spectrum Test Prep, Grade 1*. United States: McGraw-Hill Consumer Products, 1999.

### MOM SEARCHES THE WEB

Gabe's mother searches the web, entering "place value" and "first grade" in the Google search engine, and finds 5,310 URLs. The entries near the top of the list are not much help. (See Figure 2. *Google Place Value Sites*). They deal with manipulating words and symbols rather than focusing on what the "hard part" is for a child.

aaamath.com	education.jlab.org	funbrain.com

Figure 2. Google Place Value Sites

Gabe's Mom tries the PBS web site, and using the "find" function, discovers an activity that resembles a school workbook exercise. It stays within "hundreds," which matches the test better, and involves rearranging numerals in a way that takes some thought. Since the activity doesn't work on the screen (it's not interactive), she prints it out. The directions ask Gabe to "rearrange the digit cards to form the largest and smallest number," using 0, 3 and 8 (See Figure 3. *Workbook Page on the Web*). Gabe chooses 8 as the largest number and 0 as the smallest, and insists he is right, even though his mother explains that he should be using all three numbers to come up with his answers. Gabe is not convinced she is right.

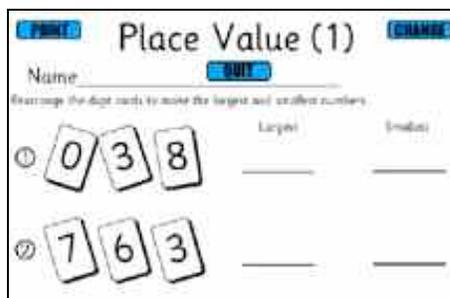


Figure 3: Workbook Page on the Web (PBS.org)

Gabe's Mother asks the after-school caregiver at the YMCA for ideas, and hears that a favorite web site of the children has a particular activity that might help. (See Figure 4. *Place Value Activity*). Gabe's mother notices that this jazzy game will help convince her son that he has to use all three numbers, and he can click numbers on the screen and get some feedback to make it work, so she bookmarks this site. When Gabe comes home, he

sees a colorful screen with a 3-digit number machine. He clicks each of 3 numbers 2, 2 and 4 trying to make a number larger than 857, but he can't do it. Gabe hasn't noticed the button, "Can't be done." The program tells him his answer is wrong but doesn't explain why, or tell him how to fix it, and it doesn't address the concept of place value for someone who doesn't already know it. Gabe still doesn't grasp the place value concept and this activity hasn't provided much help.

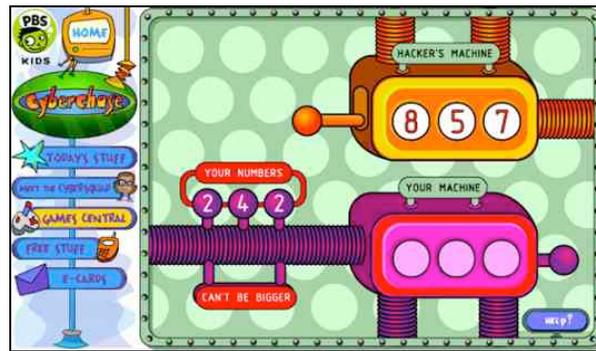


Figure 4: Place Value Activity (PBS.org)

Gabe's Mom makes one more try, looking at edutainment software at Costco. There are lots of titles with Sponge Bob and other TV characters, and it's hard to tell what's in the programs from the covers. She's heard that kids like titles from the Learning Company, so she buys *Reader Rabbit Personalized 1st Grade*. In the manual, she reads about *Costu-Matic*, an activity that "lets children practice counting coins up to \$1.00 in total value." That sounds practical and like it might teach place value, so she pops the disk into the family computer. Gabe likes playing the various activities, such as arranging turtles with the days of the week written on their backs, and finds his way to *Costu-matic*. This game uses coins in base 5 (nickels, quarters) and base 10 (dimes), so it doesn't focus in on place value. It gives practice in adding with multiples (1s, 5s, 10s, 25s) but there is no conceptual support for the "hard parts." All these quantities come up at once and the answer is right or wrong. Gabe can put any coins in a slot without much thought and succeed, but there isn't any conceptual support or "build" that keeps him "on his learning edge." Gabe gets along fine with trial and error, like most edutainment software, and soon loses interest. (See Figure 5. *Reader Rabbit Coin Game*).



Figure 5. *Reader Rabbit Coin Game*

Gabe's mother keeps track of how long he uses this software, and is disappointed when he comes back for only one hour all together. The games deliver practice on a few skills but no conceptual understanding. She has Gabe try *Treasure Math Storm* and finds that he likes it, but the place value game in the Crystal Cave has arrays of ten crystals in piles of 3, 4 and 3. Gabe has to count by tens to answer, so that gives some practice in a place value skill, and he has to type an answer with 2 places, but it's not getting to the heart of the matter of how the digits work.



She has heard that Leap Frog products are best sellers, so she finds a Leap Pad. It has a stylus for touching "hot spots" on book pages, and the book "talks." She finds Leap Math 1 for Gabe. It comes with a colorful 24-page book and a cartridge. For place value, it has one page that might help--a page of football playing animals with numbers 1-20 on their jerseys and typed on their helmets. Maybe Gabe can learn to read these numbers for the test. But the Leap Pad won't help much, it spans 3 years of learning in 24 pages. There seem to be the same exercises in all the kids' products (use a few coins, count to 20, name the shapes, read a clock), but none of them build understanding step by step.

Now most people would give up, but not Gabe's Mom. She searches the web site of Houghton-Mifflin, the publisher of Gabe's math book, and finds organized and clear resources for teachers and parents. She does a search on "place value" and finds some nifty information--that place value is "the basis of our entire number system base ten block activities in second grade." That sounds pretty important. She reads on:

"Place value is vitally important to all later mathematics. Without it, keeping track of greater numbers rapidly becomes impossible. (Can you imagine trying to write 999 with only ones?) A thorough mastery of place value is essential to learning the operations with greater numbers. It is the foundation for regrouping ("borrowing" and "carrying") in addition, subtraction, multiplication, and division."<sup>2</sup>

And she finds some activities for second graders. (See Figure 6. *Houghton Mifflin Place Value Activity*). But she's not sure how she'll get Gabe to do these at home, so she approaches Gabe's teacher again.

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<sup>2</sup> <http://www.eduplace.com/math/mathsteps/2/a/index.html>

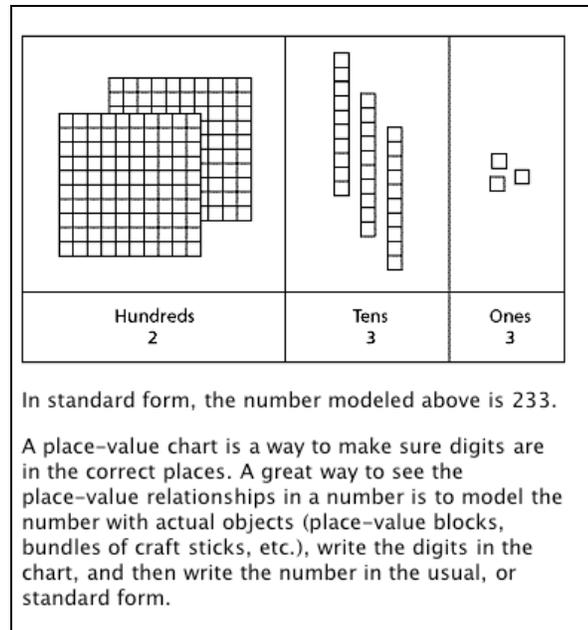


Figure 6. Houghton Mifflin Place Value Activity

### TEACHER DIGS INTO MATH LITERATURE

Gabe's teacher knows place value is important, and decides to look up more about the topic. She finds that overview of goals in the *National Council of Teachers of Mathematics (NCTM) Principles and Standards* includes place value:

In pre-kindergarten through grade 2 all students should—

- Use multiple models to develop initial understandings of place value and the base-ten number system.
- Develop understanding of the relative position and magnitude of whole numbers and of ordinal and cardinal numbers and their connections.
- Develop a sense of whole numbers and represent and use them in flexible ways, including relating, composing, and decomposing numbers.<sup>3</sup>

But the teacher doesn't find details about first grade (guidelines are for pre-K-2). She also doesn't find the steps to take in teaching place value to her class. She respects NCTM, so looks further and finds a book on sale, *Mathematics for the Young Child*.<sup>4</sup> She has seen this fine book! It's really solid, even though it's 13 years old.

Gabe's teacher reads up on place value in *Chapter 5. Place Value and Larger Numbers*, by Charles Thompson. He points out that children must first develop the concept of a group as a single entity and should use ungrouped objects (e.g. beans, Multilinks, sticks) to form groups and break them apart. (See *Figure 7. Place Ten Materials*).

<sup>3</sup> <http://standards.nctm.org/document/chapter4/numb.htm>

<sup>4</sup> Payne, Joseph N. (Ed). *Mathematics for the Young Child*. Reston, VA: National Council of Teachers of Mathematics, 1990. (Recommended on NCTM.org 2003 web site), p.93.

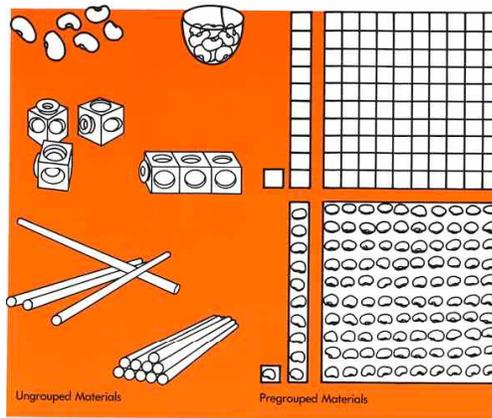


Fig. 3. Place-value materials

Figure 7. Place Ten Materials<sup>5</sup>  
Grouped and ungrouped

After children grasp the “part-part-whole” concept, they can use pre-grouped, proportional materials such as base ten blocks for place value activities. But these have the disadvantage that even though the materials are sized according to the numbers they represent, children might not notice or grasp this.

#### TEACHER FINDS NEW KIND OF SOFTWARE ON THE WEB

Gabe’s teacher has many students at various levels of mastery. She knows that there are many fine activities recommended by the NCTM book, but she doesn’t have a lot of time to research another chapter (about part-part whole), or to arrange special activities for each child, so she turns to software to solve the problem.

Long ago her district purchased a set of MECC software called *Math Keys*.<sup>6</sup> She looks through her old diskettes and finds an open-ended program that lets students explore place value. It's got nifty features--students can write problems and the blocks move or move blocks and see problems appear, with the labels on the columns changing and the problem appearing horizontally and vertically. Children can move blocks filling a 10-frame over to the next column, revealing their place value property. The program has a "machine voice" that prompts children if they do something wrong, such as trying to place unit blocks in the hundreds column. (See Figure 8. *Math Keys*).

But the program is so open-ended that it seems more like a tool for doing problems after the basic concepts of place value are clearer. She'd rather the screen matched physical blocks better so students are encouraged to carry out the activities off screen, and it seems a bit too automatic. She doesn't think Gabe will come back to this program

<sup>5</sup> Payne, Joseph N. (Ed). *Mathematics for the Young Child*. Reston, VA: National Council of Teachers of Mathematics, 1990. (Recommended on NCTM.org 2003 web site), p. 92

<sup>6</sup> *Whole Numbers, Vol. 1-Grade 1*, Version 1.1 MECC, 1994. (MECC purchased by The Learning Company, then Mattel, then RiverDeep)

working independently. She wishes the numerals (e.g. 111) were lined up so they match the blocks. She decides to keep looking for a program to introduce the basic place value concepts, but fires up this program for children ready to enter and check their own problems. She's glad she found this set of programs again! They are easy to use and can accommodate problems at many levels.

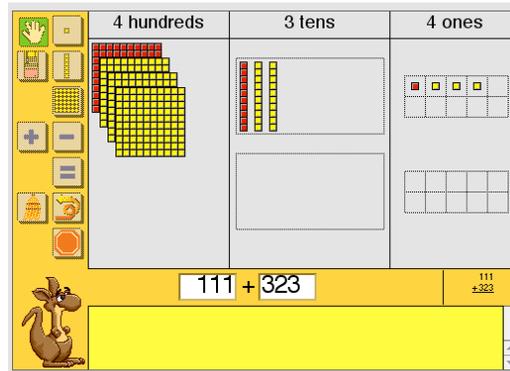


Figure 8. *Math Keys*  
from MECC/TLC/Riverdeep

Then Gabe's teacher agrees to participate in a field test of a new program on the Internet, *Miranda's Math: Zak Learns Place Value*. This program looks like it came right out of the Houghton Mifflin series or the NCTM math book, but it guides the children step by step focusing precisely on what's hard about the fundamental concepts. Gabe's teacher downloads the program free at:

<http://www.learningfriends.com/download>

Previewing *Miranda's Math*, the teacher notices a special kind of base ten blocks--proportional, ungrouped blocks that click together to form grouped objects, and come apart to form new wholes. (See *Figure 9. Base Ten Blocks*) *Miranda's Math* uses these unique "crossover manipulative" (featuring the advantages of both the ungrouped and pre-grouped objects Payne talked about). These blocks, invented by Mary Laycock, the senior mathematics advisor to Learning Friends, are great for overhead projector use, and the red ones can show negative numbers, too.

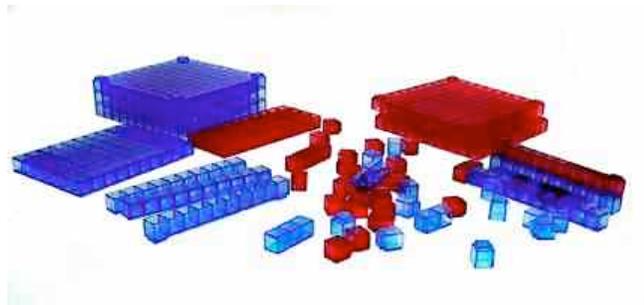


Figure 9. Base Ten Blocks

Gabe's teacher convinces the curriculum coordinator to order a set of these blocks and sets up a station for Gabe and his friends. They explore the properties of the blocks while building objects they like, such as a parking garage. (See *Figure 10. Base Ten Parking Garage*).



Figure 10. Base Ten Parking Garage

In the process of playing, Gabe notices the sizes, shapes and numbers associated with the blocks. Gabe clicks together 10 units to form a long; 10 longs to form a flat and 10 flats to form a cube. Gabe and a couple of his friends pass the Learning Friends' pre-test for readiness, and show that they are not too advanced to benefit by playing the game. He's ready to go!

**GABE PLAYS MIRANDA'S MATH: ZAK LEARNS PLACE VALUE**

Gabe watches a 3-minute story about Zak, a bold raccoon about his age, playing a trick on Miranda Dragon and showing off his prowess. Gabe is frightened of big things like dinosaurs, and the hulking size and friendliness of Miranda delights him. Zak Raccoon reminds Gabe of his friends, who are constantly active, trying new stunts, and liking to brag. (See Figure 11. *Zak Lands with a Thud*.) The opening also introduces the terms and procedures for playing



Figure 11. Zak Lands with a Thud



Figure 12. Place Value Activity  
Place Value Board (purple object)  
Blue base ten blocks: flats (100s), longs (10s) and units (1s)  
Scrolling counting strip (1's column has numerals entered)  
The tail of Miranda Dragon

Gabe says, "This is easy! I can do this!" He sees the units, longs and flats on the place value board, and the counting strip (See *Figure 12. Place Value Activity*). Gabe pulls down "units" and types numerals for each, from 1 to 9 on a "counting strip." Gabe can take in new terms while feeling successful. He doesn't realize that the game is assessing whether he knows how to recognize and type numerals as he plays. When Gabe pulls down the tenth block, he expects to write "10" right after "9" in the right column of the counting strip, but Miranda has a new idea in store. (See *Figure 13. One Minute of Guided Play*).

Miranda pops up on the screen and says,

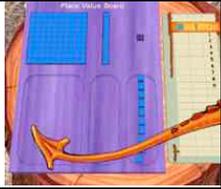
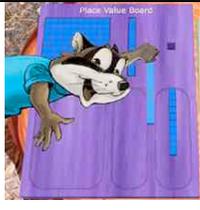
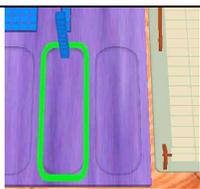
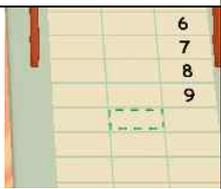
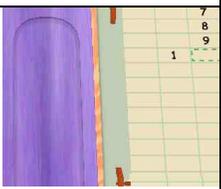
				
1 You just pulled down the tenth block! Bravo!	2 <i>Miranda's tail straightens up blocks the child has placed.</i>	3 Zak, see if these ten units match one of the long blocks.	4 Sure thing.	5 <u>This</u> is a long.
				
6 I'm moving the long next to these ten units.	7 Humm, would you check it for me?	8 Yup, the long is the same as ten unit blocks.	9 Now let's move the long into it's own longs column.	10 <i>Hum puts away the units.</i>
				
11 How many longs do we have?	12 Type the number in the ones column <i>Child types 1</i>	13 How many units are there in the ones column? <i>Child types 0</i>	14 You counted to 10! Now can we go to the magic cabinet?	15 Of course!

Figure 13. *Miranda's Math*: One Minute of Guided Play

*The characters provide very specific help in understanding place value. Gabe completes the activity to 100 on screen, putting together ten units to make a long, comparing these with a pre-formed long, and moving the long to it's own longs column. He does this ten times, and finally forms a hundred with the longs, comparing these with a flat, and moving the flat to its own flats column.*

He enjoys seeing the pattern of writing 1 in the hundreds column, and zeros in the tens and ones columns. He's really getting the idea!

Every time Gabe plays, Learning Friends sends a brief email message to several family members. Gabe's grandmother, who has email service, receives news of how far along he is, and calls Gabe to ask a couple questions (primed by the email), and she congratulates him warmly. When Gabe's Dad comes home from work, Gabe shows how he does the place value activity off screen, using real base ten blocks and a place value board he made himself. Gabe is proud of his counting strip, which is getting longer and longer. Gabe's Dad helps him paste adding machine paper onto the counting strip so he can count up to 1,000 using base ten blocks to model each number. Gabe likes having his family know how well he's doing.

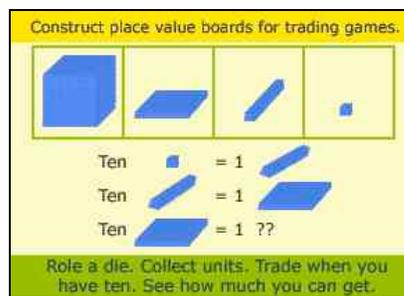


Figure 14. Place Value Game

Gabe likes the activity so much that his family helps him try variations in base 5, using blocks and coins (pennies, nickels and a quarter), and in base 2, which is fun because he reaches 1,000 so quickly. He enjoys making "base 2 blocks" and his grandmother exclaims that he's not supposed to know such things when he's in first grade! Gabe tries a game with a die and blocks, making his own place value board, and shows his friends how to play. (See Figure 14. Place Value Game). Gabe never has trouble with place value again. Gabe's teacher is so pleased with his renewed enthusiasm, she downloads the game for the whole class and joins an ongoing discussion in a weblog with Learning Friends. She looks forward to sharing many more "hardest concept" games with her class, which she knows are in development.

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