NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS

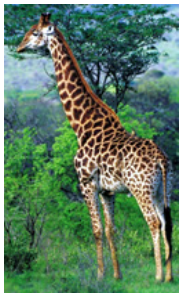
Problem of the Week Teacher Packet

Zoo Train

The zoo has a train that carries people between exhibits. One morning the first passengers got on at Monkey House. At Alligator Pond the number of people who got on was 3 more than got on at Monkey House.

The train made 4 more stops: Tiger Thicket, Panda Playground, Giraffe Savannah, and Big Cats. At each of these stops, 3 more passengers boarded the train than at the previous stop. At Big Cats 20 people got on the train. How many passengers in all boarded the train?

Extra: What is the minimum (fewest) number of train cars that it would take to hold all those passengers at once, if each car holds 12 passengers?



Answer Check

After students submit their solution, they can choose to "check" their work by looking at the answer that we provide. Along with the answer itself (which never explains how to actually get the answer) we provide hints and tips for those whose answer doesn't agree with ours, as well as for those whose answer does. You might use these as prompts in the classroom to help students who are stuck and also to encourage those who are correct to improve their explanation.

Seventy-five (75) passengers boarded the train in all.

If your answer **doesn't** match ours,

- did you realize that the number of passengers that boarded the train at each stop was 3 more than at the previous stop?
- did you make a list of all the stops in order and work backwards from Big Cats?
- did you try to find out how many passengers got on at each stop?
- did you try acting out the problem with chips or a number line?
- did you check your arithmetic?

If you used guess and check, did you tell . . .

- what numbers you tried?
- how you tested them?
- how you knew whether they worked or not?
- how you decided what to try next?

If any of those ideas help you, you might revise your answer, and then leave a comment that tells us what you did. If you're still stuck, leave a comment that tells us where you think you need help.

If your answer **does** match ours,

- is your explanation clear and complete?
- did you try the Extra questions?
- did you verify your answers with another method?
- did you have any "Aha!" moments or notice any patterns? Describe them.

Revise your work if you have any ideas to add. Otherwise leave us a comment that tells us how you think you did—you might answer one or more of the questions above.

Our Solutions

Method 1: Work Backwards

I made a list of all the stops in the order that people got on. I wrote 20 next to Big Cats, since 20 passengers got on there. I knew that was 3 more than got on at Giraffe Savannah, so I subtracted to find out how many got on there.

20 - 3 = 17 passengers

I kept working backwards, subtracting 3 for each previous stop until I got to Monkey House, where I found 5 passengers boarded the train.

17 - 3 = 14
14 - 3 = 11
etc.

I added the number of passengers that got on at each stop and found that a total of 75 passengers boarded the train.

5 + 8 + 11 + 14 + 17 + 20 = 75

I noticed that I could make 3 pairs of 25 from these numbers, making it easy to add:

(5 + 20) + (8 + 17) + (11 + 14) = 75

I checked my answer by starting at 5 and adding another 3 for each other stop. I came out with 20 for Bid Cats, so I know I have the right number of passengers at each stop.

Method 2: Work Backwards and Make a Table

I used a table to make a list of all the stops in the order that people got on. In the second column of my table I listed 20 next to Big Cats because the story says that 20 passengers got on there. My table looked like this:

Stops	**Passengers boarded**
Monkey House	
Alligator Pond	
Tiger Thicket	
Panda Playground	
Giraffe Savannah	
Big Cats	20
Total	?

Next I subtracted 3 from 20 to find out how many passengers boarded at Giraffe Savannah. I entered 17 into my table. I subtracted 3 from 17 to find out the number of passengers who boarded at Panda Playground. I entered 14 in my table and I continued doing that for the other three stops until my table was filled in except for the Total. My last step was to add:

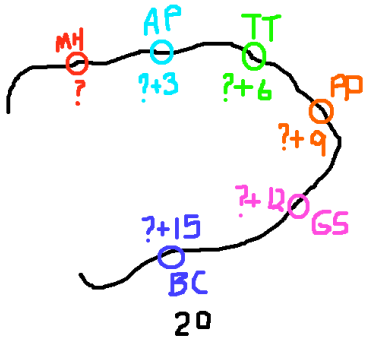
5 + 8 + 11 + 14 + 17 + 20

My answer for the total is 75.

Stops	**Passengers boarded**
Monkey House	(8 – 3) = 5
Alligator Pond	(11 – 3) = 8
Tiger Thicket	(14 – 3) = 11
Panda Playground	(17 – 3) = 14
Giraffe Savannah	(20 – 3) = 17
Big Cats	20
Total	75

Method 3: Make a Picture

I drew the route of the Zoo Train on paper. I drew a circle at Monkey House to stand for the number of passengers that got on there. At Alligator Pond I drew a circle and wrote (? + 3) because 3 more passengers got on than at Monkey House. At Tiger Thicket I drew a circle and (? + 6), since 3 more got on than at Alligator Pond. At Panda Playground I drew a circle and (? + 9). At Giraffe Savannah I drew a circle and (? + 12). At Big Cats I drew a circle and (? + 15).



Since the problem said 20 passengers got on at Big Cats, I knew ? + 15 = 20. Then I knew the ? equals 5 and also that 5 passengers got on at Monkey House. I used my drawing to think about the number of passengers that got on at each stop. I added them together and found that 75 passengers got on altogether.

5 + 8 + 11 + 14 + 17 + 20 = 75

Method 4: Guess and Check

I tried different starting numbers for the passengers that got on at Monkey House (MH). I added the extra 3s at each step and found out how many would get on at the last stop. I started with 10 and put my results in a table. When I saw that starting with 4 less (from 10 to 6) resulted in 4 less at Big Cats, I knew I just had to start with one less to decrease Big Cats to 20.

MH	AP	TT	PP	GS	BC	Does it work?
10	13	16	19	22	25	too many, by 5
6	9	12	15	18	21	still too many, by 1
5	8	11	14	17	20	yes!!

Five passengers got on at Monkey House. I added them together:

5 + 8 + 11 + 14 + 17 + 20 = 75

I found that 75 passengers got on altogether.

Method 5: Collecting 3s

I counted how many extra groups of 3 got on at all the stops. At Big Cats 5 groups of 3, or 15 more, boarded the train.

Stops	**Extra 3a**
Monkey House	0
Alligator Pond	1
Tiger Thicket	2
Panda Playground	3
Giraffe Savannah	4
Big Cats	5
Total	15

The same number of passengers that boarded at Monkey House also got on at each stop in addition to the extra 3s. The 20 passengers that boarded at Big Cats is 5 more than the sum of the extra 3s, so I knew that 5 passengers boarded at Monkey House.

To find the total of the passengers I added the total of six 5s and all of the extra 3s.

$(6 \bullet 5) + (15 \bullet 3) = 30 + 45 = 75$ passengers

Method 6: Algebra

I let n represent the number of passengers that got on at Monkey House. At each stop 3 more passengers boarded the train than at the previous stop.

Stops	Passengers boarded
Monkey House	n
Alligator Pond	$n + 3$
Tiger Thicket	$n + 6$
Panda Playground	$n + 9$
Giraffe Savannah	$n + 12$
Big Cats	$n + 15$
Total	$6n + 45$

Since 20 passengers board at Big Cats, n + 15 in the chart, n = 5.

$5 + 15 = 20$

The total of the passengers is 6n + 45.

$6 \bullet 5 + 45 = 30 + 45 = 75$ passengers total

Standards

If your state has adopted the Common Core State Standards, you might find the following alignments helpful.

Grade 3: Operations & Algebraic Thinking

Solve two-step word problems using the four operations. Represent these problems using equations with a letter standing for the unknown quantity. Assess the reasonableness of answers using mental computation and estimation strategies including rounding.

Grade 4: Operations & Algebraic Thinking

Solve multistep word problems posed with whole numbers and having whole-number answers using the four operations, including problems in which remainders must be interpreted. Represent these problems using equations with a letter standing for the unknown quantity. Assess the reasonableness of answers using mental computation and estimation strategies including rounding.

Generate a number or shape pattern that follows a given rule. Identify apparent features of the pattern that were not explicit in the rule itself.

Grade 5: Operations & Algebraic Thinking

Write simple expressions that record calculations with numbers, and interpret numerical expressions without evaluating them.

Mathematical Practices

1. Make sense of problems and persevere in solving them.
3. Construct viable arguments and critique the reasoning of others.

Teaching Suggestions

Zoo Train requires understanding that at each successive stop, the number of passengers that boards the train is 3 more than boarded at the last stop. One possible way to misinterpret the problem is to think that "3 more" people get on the train at each stop. The questions in the answer check above can be useful in helping students who are struggling or who have a misconception.

There are a number of ways to approach Zoo Train. I expect many students to work backwards, beginning with the 20 passengers who got on at the last stop, and subtracting three at a time to calculate each previous stop. Tables can provide an effective way to organize and represent this kind of thinking.

Students who approach the problem with a guess and check strategy (Method 4 above) need to make use of the information gained from incorrect attempts in order to make a better next guess – achieving success through skill and understanding, not pure luck. See the answer check for more details. You might want to encourage students to find an altermative approach to verify their answers.

The Extra asks solvers to find how cars with a capacity of 12 passengers it would take to carry all 75 passengers. Division is the most direct way to solve it. A solver needs to recognize the need to round the quotient up, since any remainder requires an additional car. Children who have not learned to divide may solve the Extra by using multiplication or repeated addition or subtraction until they find the number of cars needed.

Sample Student Solutions – Focus on *Clarity*

In the solutions below, I've provided scores the students would have received in the **Strategy** category of our scoring rubric. My comments focus on areas in which they seem to need the most improvement.

Novice	Apprentice	Practitioner	Expert
Explanation is very difficult to read and follow.	Another student might have trouble following the explanation. Long and written in one paragraph. Many spelling errors/typos.	Explains the steps that they do explain in such a way that another student would understand (needn't be complete to be clear). Uses level-appropriate math language. Makes an effort to check formatting, spelling, and typing (a few errors are okay).	Format and organization make ideas exceptionally clear. Answer is very readable and appealing.

Mohamad, age 10, Novice

a total of 75 people boarded the train at the end.EXTRA:it would take a minimum of 7 trains.

i wrote all the places visited down.then i strated subtracting 3 from the big cats until i got to the last place visited.EXTRA:i divided 75 by 12 because that's how many people could fit on each train.

Mohamad appears to have solved the problem correctly, but a peer would have difficulty reading it and understanding his steps. A peer could help him edit. More detail is needed. I'd question him about "the last place visited."

Ian, age 13, Novice

No, In total, 75 passengers boarded the train at this zoo Extra: It would take 7 cars with a capacity of 12 people each to hold all of the people.

First, I amde a table withe everything I knew about the stops like how many people got on at the stop, or how many more people got on than at the last one. for the 1st two stops, not much information was given, except that 3 more people got on than at the last stop. Then, it told you that at the next 3 stops, the same thing happened. For all the stops, 3 more people got on than at the last stop. Then, at the last stop, 20 people got on. So, to find out how many people got on at each stop, you would subtract 3 each time, descending from 20, to get my answer. You would get 5 people on at monkey house, 8 at alligator ond, 11 at tiger thicket, 14 at panda playground, 17 at giraffe savannah and 20 at big cats. adding them togather, you get 75 people. EXTRA: To see how many 12 person cars you will need for a group of 75, divide 75 by 12. you will get 6.25. But, .25 of cars dont exist, so you have to round it up to 7 cars.

Ian includes more detail, but given his age, his writing is not well organized and contains errors that interfere with our understanding. The details of his math would be much easier to read in table or list form. I'd ask him to include some calculations, including the one to arrive as his final answer.

JP, age 10, Apprentice

20 people got on the train at Big Cats.17 people got on the train at Giraffe Savannah.14 people got on the train at Panda Playgound.11 got on at Tiger Thicket.8 got on at Alligator Pond.5 got on at The Monkey House. EXTRA: You would need 7 cars.

I found my answer by minising three from each number I got.Then I added up all of the numbers.Then I divided that number by twelve and got my answer for the extra.

JP didn't answer the main question. In addition to adding more detail, including rationale, I'd ask to see some calculations and ask for his findings in a list/table. He should use "subtracting" rather than "minising." What number did he divide by 12 for the Extra?

Matt, age 9, Apprentice

Alana's 75 people boarded the train.Extra:The minimum amount of train cars there were is 7.

First, I knew that there were 20 people that boarded the train at Big Cats and before that 3 people less boarded the train there. 20-3=17.I did that because 20 people got on at Big cats, 3 less would make 17. That meant 17 people boarded the train at Giraffe Savannah. Once again,I took 3 away. 17-3=14.Taking 3 away will help me find my answer because the problem said that each time there were 3 more people on. 14 people

boarded the train at Panda Playground. Same thing 14-3=11. 11 people boarded the train atTiger Thicket. Same thing,once again,11-3=8.8 people got on the train at Alligator Pond. Finally 8-3=5. 5 people boarded the train in the beginning.Now I added **5+8=13+11=24+14=38+17=55+20=75**. I added all those numbers to find how many people were on the train. 75 people boarded the train. Extra: 75 divided by 12= 6R3.I did that to find out how many train cars.I divided because if there were 75 people if you subtracted there would just be less people and if you multiplied there would be a huge amount of train cars. Since all 75 people have to be on the train, 7 cars is the minimum amount of cars on the train.

Matt expressed his thinking clearly. We'd work on representing his steps in list or table form. He needs to learn how to write his long addition sentence (in bold) in more conventional form. "Gluing" equations like this is common, but it creates an invalid statement.

Maddie, age 9, Practitioner

So I got 75 people boarded the train.

First I wrote all the names of the places the train stopped. I wrote a 20 next to Big Cats because that is how many people boarded the train there. Then I took 3 away (because every stop 3 more people got on the train than on the last stop.) I kept taking away three from the stops until I reached Monkey House. This is the chart I made to record that:

Name Of Exhibit	Number Of People Boarding
Monkey House	5
Alligator Pond	8
Tiger Thicket	11
Panda Playground	14
Giraffe Savannah	17
Big Cats	20

Then I added the number of people boarding on each stop and got 75. So I got 75 people boarded the train.EXTRA First I skip counted by 12. 12,24,36,48,60,72... I knew I couldn't stop there because there are 75, not 72 people so I kept going...84. I knew that was more than 75 so I counted how many 12s there where and I got 7. So my answer is you need 7 cars.

This is a solid age-appropriate explanation. Maddie's list helps us easily know how many passengers boarded at each stop. I'd ask her to clarify her language a bit to make more explicit the fact that she worked backwards.

Archit, age 11, Expert

There were at the end 75 passengers.

Lets say that at the monkey house, x people got on the train.
At the alligator, 3 more people got on the train, x +3.
In total there is currently 2x + 3
At each of the for more stops, 3 more people than the last stop get on;
Tiger Thicket: x + 6
Panda Playground: x + 9
Giraffe Savannah: x + 12
Big cats: x + 15
The total sum is 6x + 45
The problem tells us that 20 people boarded the train at big cats,
so x + 15 = 20.
If solved;
x + 15 = 20
x = 20 - 15
x = 5
After solving x, I put it into the formula;
6x + 45
6(5)+45
30 + 45
.: 75 people boarded the train

EXTRA: I found how much 12 would go into 75. 75/12 = 6 R3.
You cannot leave 3 passangers stranded, so those 3 passengers would require another car.
Therefore they will need 7 cars.

Archit's algebraic approach would earn him Expert in Strategy. The fact that, as an 11-year-old, he correctly formats his equations identifies his variable and provides clear rationale earns him Expert in Clarity as well.

Arman, age 9, Expert

75 people got on the train.

Extra. 7 train cars.

I knew that 20 people got on the train at Big Cats. Since I know at each previous station 3 less people get on:

At Giraffe Savannah 20-3=17 people got on;
At Panda Playground 17-3=14 people got on;
At Tiger Thicket 14-3=11 people got on;
At Alligator Pond 11-3=8 people got on;
At Monkey House 8-3=5 people got on.

So the total is 20+17+14+11+8+5=75.
Extra. I knew only one train car can carry 12 people so I tried 12*1=12 then 12*2=24. Then I tried 12*3=36 then 12*4=48. Then I tried 12*5=60 then 12*6=72 and then I thought 6 train cars isn't enough so you have to have 7 train cars but one train car will not have 12 people.

An exceptional 9-yr old's effort, Arman's explanation is succinct but includes all the detail we need to understand his thinking. He sequences it to match his process and makes good use of multiplication for the Extra.

Frogs (team), age 9, Expert

75 passengers boarded the train.

We made a T-chart of all the different stops.
We began with a guess and check strategy. We guessed 3 passengers at Monkey House.

Each Stop	# of People
Monkey House	3
Aligater Pond	6
Panda Playground	9
Tiger Thicket	12
Giraffe Savannah	15
Big Cats	18

3+3+3+3+3+3=18 which was too low.

Then we tried 5 because it is a multiple of 20.

Each Stop	# of People
Monkey House	5
Aligater Pond	8
Panda Playground	11
Tiger Thicket	14
Giraffe Savannah	17
Big Cats	20
+	_____
	75

We knew that Big Cat had 20 passengers get on the train.

A better strategy would be to count back from 20 by 3 until all of the stops were filled.

Extra:There are 7 train cars but one of them is not completely full.
We kept adding groups of 12 until we got close to 75.

This team has organized and formatted their work in a way that makes their ideas exceptionally clear. I would model a more correct form for their final equation of the Extra.

12+12+12+12+12+12=72 The closest we got was 72 and we knew we had to go over or people would be left over. So we added another car.
12*7=84-75=9 seats left over

Scoring Rubric

A **problem-specific rubric** can be found linked from the problem to help in assessing student solutions. We consider each category separately when evaluating the students' work, thereby providing more focused information regarding the strengths and weaknesses in the work.

We hope these packets are useful in helping you make the most of the Math Fundamentals Problems of the Week. Please let me know if you have ideas for making them more useful.

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