Following on the heels of my past two articles discussing how much we can do with food data in a math classroom, especially fast food like Starbucks, in middle school, I thought it might be fun to consider how we can look at linear relationships connected to healthy movement. I was not surprised to read in the 2012 and 2013 Canadian Healthy Measures Survey that most school aged-children and youth are not getting enough physical activity, but I was shocked to read that only 3 percent of girls 12 to 17 meet the recommendations and only 18 percent of boys in the same age range.

Now, the five-minute burst of physical effort that the students endure through this activity might not be the 10 minutes recommend bout, but it is a start! This article includes samples of student work (thanks Sarah and Thea for letting me include their TI-NSpire files and their written answers) and some sample student scenarios. You might want to also notice the focus on multiple representations for this activity in what my students like to call "window-pane" charts.

This is another two-part activity with the first part originating from the students' own movement. The next issue will feature a more traditional assessment (like questions that could be done on a test) with the same framing and the same "window-pane" charts and scenarios that arose from doing these problems in my Grade 9 classroom.

LINEAR LEAPING

In Physical Education class, you often learn how to improve your physical fitness by repeating exercises with good form. These exercises might include burpees, bench-ups, side-to-side jumps, and jumping jacks.

Group Discussion Question

1. Can you maintain a pace in your exercising for 5 minutes that keeps your rate of exercise constant throughout the entire time?

Group Investigation

- Choose **one exercise** that you will try to maintain a **consistent pace for 5 full minutes**.
- In your group, each person in the group must complete a different exercise. In your group, you rotate through the following roles: **exerciser, counter, timer/recorder, and trainer (motivating and checking form)**.

Each exerciser will do the following:

- Warm up by completing your exercise from 5-20 times. Make sure that other members of your group count, record, and check the exercise's form. Use these warm-ups as practice for the roles.
- Once you have warmed up and you are consistently able to do your exercise with good form and your group members can do their tasks efficiently, begin the experiment.
- *The final number of warm-ups you do is the starting value of the experiment.* The recorder/timer will measure over five minutes the **appropriate intervals of time**, while the counter keeps track of the total number of correct exercises you have completed. You should also keep track of how many exercises you have completed over that time. Throughout this experiment, you should attempt to try to keep your rate of exercise as consistent as possible. You should have at least 5 pieces of data beyond the initial warm-up value.
- Record your results in a table that shows the time elapsed and the total number of exercises completed.
- Rotate through the roles so that each person conducts the exercises and collects the data.

Individual Analysis – Part One

Be sure that each person has the data that they created for their exercise (not the data they collected). The work will be done **on your own**.

Take a rest from the leaping and move onto to the linear…

<table>
<tr><td>Graphical
(Draw a sample sketch)</td><td>Logical
(Explain the starting value,
and constant change rate in words)</td></tr>
<tr><td>Graph your data showing the key points.</td><td>You started at _____,
you performed at a rate of _____.</td></tr>
<tr><td>Algebraic
(State the variables and the equation)</td><td>Numerical
(Complete the table,
being sure to show important points)</td></tr>
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</table>

1. **K** Is your data linear? Justify your response in at least two ways.

2. Assume the data does have a linear relationship (regardless of your above answer).
   a. **K** Determine the equation of the line (using technology) for this data.

   b. **K, A** What is the slope of this line? Comment on what this value means realistically.

   c. **A** What is the y-intercept of this line? Comment on what this value means realistically.

   d. **K, A** Using your linear model, how many exercises could you do in 20 minutes (whew!)? Confirm your response using the equation and the graph.

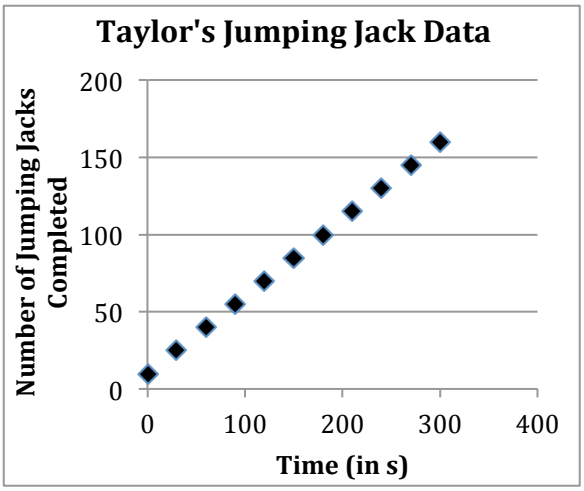
   e. **K, A** Using your linear model, how many minutes would it take to do 400 exercises? Confirm your response using the equation and the graph.

3. **T, C** If you decided to exercise at your full potential, instead of trying to perform at a consistent rate, describe how you think the data and the linear model would change.

Individual Analysis - Part Two

How would this scenario extend beyond your exercising experience? You might be curious how fancy and fit these students are if they were to do these too.

4. **A, C** Taylor is a regular exerciser and Lucy created his graph. Complete this chart.

<table>
<tr><th>Graphical
(Draw a sample sketch)</th><th>Logical
(Explain the starting value,
and constant change rate in words)</th></tr>
<tr><td>Graph your data showing the key points.

</td><td>Taylor started at _____,
and performed at a rate of _____.</td></tr>
<tr><th>Algebraic
(State the variables and the equation)</th><th>Numerical
(Complete the table,
being sure to show important points)</th></tr>
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5. **T, C** Sasha felt chipper and fit that morning during a long warm-up, but she was mindful that she had a recovering sore ankle and she didn't want to injure it again. So although Sasha conducted the Jumping Jacks, she was very gentle during her workout. Compare Sasha's workout to Taylor's in this chart.

<table>
<tr><td>Graphical
(Draw a sample sketch)</td><td>Logical
(Explain the starting value,
and constant change rate in words)</td></tr>
<tr><td>Graph your data showing the key points.</td><td>Sasha started at _____,
and performed at a rate of _____.</td></tr>
<tr><td>Algebraic
(State the variables and the equation)</td><td>Numerical
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</table>

6. **T, C** How would the situation differ for Avery, who is a tremendously-fit, cardio-master, healthy exerciser, who had done 50 warm-ups ahead of time?

Graphical **(Draw a sample sketch)**	**Logical** **(Explain the starting value, and constant change rate in words)**
Graph your data showing the key points.	*Avery started at* _____, *and performed at a rate of* _____.
Algebraic **(State the variables and the equation)**	**Numerical** **(Complete the table, being sure to show important points)**
t represents the amount of time she have exercised, *n represents the number of exercises completed*	*Data collected from exercising.* **t** | **n** | | | | | | | | | | | | | | | |

7. **T, C** If Matt decided to exercise at his full potential during the warm-up, then arrived at the experiment data collecting time exhausted, describe how you think his data and his linear model would differ.

Graphical **(Draw a sample sketch)**	**Logical** **(Explain the starting value, and constant change rate in words)**
Graph your data showing the key points.	*Matt started at* _____, *and performed at a rate of* _____.
Algebraic **(State the variables and the equation)**	**Numerical** **(Complete the table, being sure to show important points)**
t represents the amount of time she have exercised, *n represents the number of exercises completed*	*Data collected from exercising.* **t** | **n**

LINEAR LEAPING – MARKING SCHEME

Learning Skills	Creates appropriate technology document and learning	Independent Work
	Document named correctly including name	Organization
	Submitted on time and in correct method	Responsibility
	Follows instructions and asks for help when productive to do so	Self Regulation
	Keeps moving with efficiency and pacing	Initiative

Part One	Graphical Display – correct information	**A**
	Graphical Display – appropriate labels	**C**
	Data Linear? 2 Justifications	**K**
	Equation of the line - correct	**K**
	Slope of the line - correct	**K**
	Slope of the line – realistic interpretation (units)	**A**
	Y-intercept of the line - correct	**A**
	Y-intercept of the line – realistic interpretation	**A**
	Correct value for exercises – using equation	**K**
	Confirmed value with graph and justified	**A**
	Correct value for time – using equation	**K**
	Confirmed value with graph and justified	**A**

Part Two	Correct interpretations of slope and y-intercept	**T**
	Explained directly the effects on the data and model	**C**
	Shows correct data tables	**A**
	Interprets the experiments in words correctly	**C**
	Correct data tables and graphs given the scenarios	**T**
	Explains the choices of data in words correctly	**C**
	Justifies the y-intercept and slope directly, and the linear model as well	**T**
	Explains the affect of the changing situations carefully and with appropriate language (not just data)	**C**

Overall	Pose problems, identify variables, and formulate hypotheses associated with relationships	Thinking Level
	Solve multi-step problems requiring numerical answers, using a variety of strategies and tools	
	Investigate the relationships between variables	
	Identify, by calculating finite differences in its table of values, whether a relation is linear or non-linear	
	Express solutions to problems in appropriate mathematical forms (e.g., in writing, formulas, charts, tables, graphs)	Communication Level
	Justify the reasoning and conclusions used in solving the problems	
	Communicate the findings of an experiment clearly and concisely, using appropriate mathematical forms	
	Describe the effect on the graph and the formula of a relation varying the conditions of a situation they represent	

LINEAR LEAPING – SAMPLE STUDENT ANSWERS

Group Discussion Question

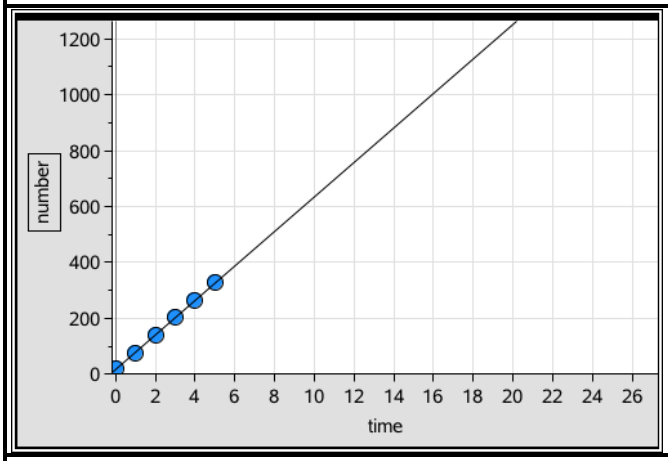
1. Can you maintain a pace in your exercising for 5 minutes that keeps your rate of exercise constant throughout the entire time?

I think the hard part is going to be constant and actually try hard to exercise. I think I will get tired and not do my best.

Individual Analysis – Part One

Sarah's answers

Graphical
(Draw a sample sketch)



Logical
(Explain the starting value, and constant change rate in words)

I started at 20 and performed at an average rate of 62 jumping jacks per minute.
62 is the average first difference, so the average number of jumping jacks I did per minute over the 5 minute period.

Algebraic
(State the variables and the equation)

t represents the amount of time you have exercised,
n represents the number of exercises completed

$n = 20 + 62t$

Numerical
(Complete the table, being sure to show important points)

Data collected from exercising.

t	n	first differences
0	20	X
1	77	57
2	140	63
3	202	62
4	263	61
5	328	65

2. *My data is approximately linear because it increases by a relatively steady rate of 62 jumping jacks per a minute. Also when I graph the line of best fit, it almost goes through all the points.*
3.
   a. Y = 17.381 + 61.7143x
   b. The slope of the line I made by hand is 62. The slope of the line on the computer is 61.7143. There are both pretty much the same. It means I did 62 jumping jacks per minute.
   c. The y-intercept of the line I made is 20. The y-intercept of the line on the computer is 17.381, meaning when the time was 0, I had already done approximately 20.
   d. At 20 minutes I would have done 1250 jumping jacks I know this from looking at the graph and following the line to 20 min. I also checked it using algebra on NSpire with my hand equation and got 1260.
   e. To do 400 jumping jacks it would have taken me approximately 6min.
      I found this by using the equation 20+62x=400
      62x=400-20,
      x=380/62,
      x=6.13
      Another way was to check the line where it goes to 400 on the graph, around 6.

4. If I exercised at my full potential and did not perform at a consistent rate my graph would not be linear. My data would increase at a higher rate at the beginning, then die down a bit in the middle because of tiredness, and then increase again at the end to finish off the 5 min. This means the data would not be consistent. It might look more like a saggy line.

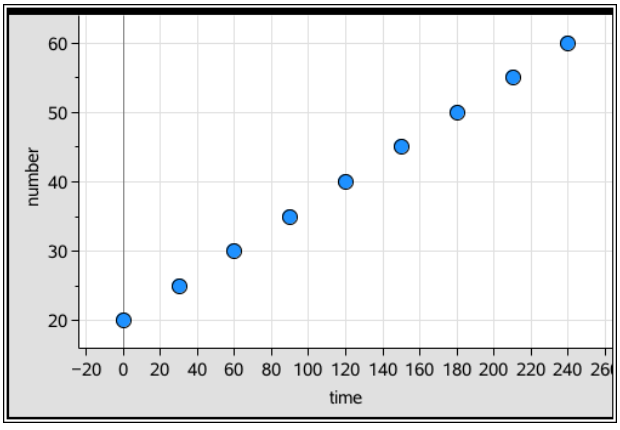
Individual Analysis - Part Two

Thea's answers

5. Logical: Taylor started at 10, and performed at a rate of 15 jumping jacks every 30 seconds.
   Algebraic: *N= 10+0.5T*

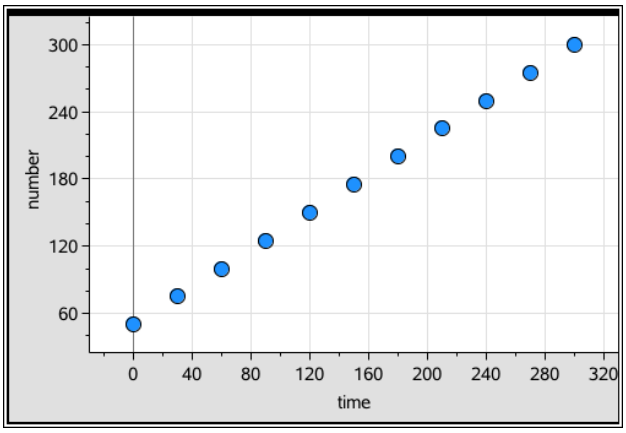
T	N		T	N		T	N
0	10		120	70		240	130
30	25		150	85		270	145
60	40		180	100		300	160
90	55		210	115			

6. Logical: Sasha started at 20 and performed at a rate of 5 jumping jacks every 30 seconds.
   Algebraic: N = 20 + 0.16T



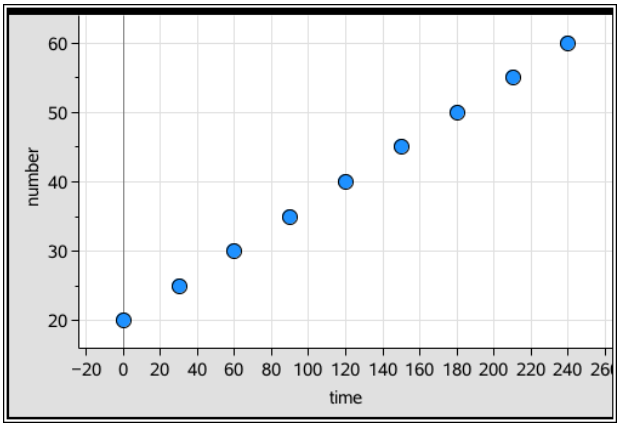
T	N		T	N		T	N
0	20		90	35		180	50
30	25		120	40		210	55
60	30		150	45		240	60

7. Logical: Avery started at 50, and performed at a rate of 25 jumping jacks every 30 seconds.
   Algebraic: *N= 50+0.83T*



T	N		T	N		T	N
0	50		120	150		240	250
30	75		150	175		270	275
60	100		180	200		300	300
90	125		210	225			

8. Logical: Matt started at 30 and performed at a rate of 2 jumping jacks every 30 seconds.
   Algebraic: N = 30 + 0.06T



T	N		T	N		T	N
0	20		90	35		180	50
30	25		120	40		210	55
60	30		150	45		240	60

The other option is that he might not be linear at all and then not have a constant rate.