LESSON DETAILS

Taking Steps towards Coding

Lesson Summary

Students will count the number of steps required to travel a given distance, such as a lap, and then analyze and graphically represent their data.

Grade: 9

Big Ideas

- Determine the relationship between the number of steps taken and the distance covered.
- Determine the equation of the line created from data collected.
- Represent a linear relationship using code.

Learning Expectations

AA1. develop and explore a variety of social-emotional learning skills in a context that supports and reflects this learning in connection with the expectations across all other strands

- building healthy relationships and communicating effectively in mathematics
- develop critical and creative mathematical thinking skills

A1. apply the mathematical processes to develop a conceptual understanding of, and procedural fluency with, the mathematics they are learning

- representing
- selecting tools and strategies

A2. make connections between mathematics and various knowledge systems, their lived experiences and various concrete applications of mathematics, including career opportunities.

B3. apply an understanding of rational numbers, ratios, rates, percentages, and proportions, in various mathematical contexts, and to solve problems

> **B3.5** pose and solve problems involving rates, percentages, and proportions in various contexts, including contexts connected to real-life applications of data, measurement, geometry, linear relations, and financial literacy

C2. apply coding skills to represent mathematical concepts and relationships dynamically, and to solve problems, in algebra and across the other strands

> **C2.1** use coding to demonstrate an understanding of algebraic concepts including variables, parameters, equations, and inequalities
>
> **C2.2** create code by decomposing situations into computational steps in order to represent mathematical concepts and relationships, and to solve problems
>
> **C2.3** read code to predict its outcome, and alter code to adjust constraints, parameters, and outcomes to represent a similar or new mathematical situation

C4. demonstrate an understanding of the characteristics of various representations of linear and non-linear relations, using tools, including coding when appropriate

> **C4.4** determine the equations of lines from graphs, tables of values, and concrete representations of linear relations by making connections between rates of change and slopes, and between initial values and y-intercepts, and use these equations to solve problems

D1. describe the collection and use of data, and represent and analyse data involving one and two variables

> **D1.2** represent and statistically analyse data from a real-life situation involving a single variable in various ways, including the use of quartile values and box plots

D2. apply the process of mathematical modelling, using data and mathematical concepts from other strands, to represent, analyse, make predictions, and provide insight into real-life situations

> **D2.1** describe the value of mathematical modelling and how it is used in real life to inform decisions
>
> **D2.4** determine ways to display and analyse the data in order to create a mathematical model to answer the original question of interest, taking into account the nature of the data, the context, and the assumptions made
>
> **D2.5** report how the model can be used to answer the question of interest, how well the model fits the context, potential limitations of the model, and what predictions can be made based on the model

Cross Curricular Connections

- Technological Education: Exploring Computer Technology (TEJ1O): Coding activities
- Healthy Active Living Education (PPL1O): Step counter activities involve exercise and step analysis. This data can be used repeatedly to analyze various factors like number of steps, average speed improvement, etc.)

Learning Goals and Success Criteria:

LG1: We are learning to collect and interpret data in connection with real situations.

SC1: I can collect data about a real situation.
SC2: I can represent data as a rate (ex: metres per second, steps per meter, steps per second) according to the context.
SC3: I can make predictions related to the data collected.
SC4: I can interpret data by doing a statistical analysis.
SC5: I can explain how one's perception of the data changes depending on the way it has been represented and analyzed.

LG2: We are learning to represent a linear relationship in multiple ways.

SC1: I can represent a linear relation with a graph, a table of values and an equation.
SC2: I can choose an appropriate representation to support interpreting data and drawing conclusions.
SC3: I can explain the meaning of the parameters "a" and "b" in the formula $y = ax + b$.

LG3: We are learning to use code to represent a real situation.

SC1: I can create working code with a chosen coding tool.
SC2: I can make corrections to my code following feedback from my teacher and my peers.

LG4: We are learning to verify a mathematical model.

SC1: I can use a model to answer a question.
SC2: I can examine my model with a critical eye to determine if it really answers the initial question.

All LGs and SCs should be reviewed and modified in collaboration with the students.

CONSIDERATIONS THROUGHOUT THE LESSON

Differentiated Instruction and Universal Design for Learning

- Discuss strategies used so that all students in the class can learn the concepts taught in this lesson.
- Review coding vocabulary.
- For a student who would need an adaptation related to the physical activity, the route to be taken and the way in which the student takes it can be modified.
- Select groups strategically so that students can help each other effectively.
- As necessary, provide organizational tools to help students collect and organize their data and switch between the three representations easily.
- Consider including choices for learning and assessment activities,
- Modify the Minds-On situation according to the interests and strengths of the students.
- Use the anticipated responses provided in the lesson to formulate prompts that might benefit students who feel stuck.

Assessment

- Throughout the lesson, the teacher will listen to mathematical discussions between the students to confirm their understanding of the concepts being studied. The teacher can use this chart to record their observations during mathematical discussions between the students.
- The representations and student notes can be collected as evidence of learning (products).
- Consolidation: Exit ticket.
- Alternatively to the exit ticket, students could prepare a question that demonstrates their understanding of the topic and then share it with a partner who will answer it and provide feedback.

RESOURCES AND LEARNING ENVIRONMENT

Educator Resources Needed

- A copy of the observation / conversation tracking chart
- Computers with block coding software
- Hard copies of the data collection chart
- Stopwatches

- Masking tape (to mark a distance of 10 m)
- Video that explains the code used to program a step counter.

Student Materials Needed

- Computers with block coding software
- Hard copies of the data collection tool
- Stopwatches

Learning Environment Considerations

To foster a positive environment, be sure to give students enough time to think about their answers when questions are asked during this activity. Encourage the use of the Think, Pair, Share strategy to promote mathematical conversations and increase student confidence.

The selection of the groups can be done in a visibly random way, or in a strategic way, in order to make for richer discussions and to get varied perspectives.

Since the lesson includes physical activity, an adequate and safe space should be chosen to ensure the safety of the students.

To make moving easier and conversations more relaxed, consider defronting the class. This encourages team collaboration and enables the teacher to triangulate evidence of learning more efficiently and effectively.

LESSON CONTENT

Minds-On (20 Minutes)

Watch the video of the 150m race between Donovan Bailey and Michael Johnson. What do you notice? What questions are you asking yourself?
Some sample questions:

- Does one athlete have an advantage? On what observations is your conclusion based?

    - Anticipated responses: The athlete starting behind the other seems to have a disadvantage, but this is due to the curve in the track, and the distances are actually the same.
- What connections do you notice between the number of steps taken and the position of the athletes?
    - Anticipated responses: Athletes follow each other closely and their steps are almost synchronized, but at some point, the pace of one athlete's steps slows down while the other remains constant.

- Ask the students if it would be possible to represent the path of the two athletes with a graph? What information would they need? What assumptions would need to be made?
    - Anticipated responses:
        - We would need to know the total distance covered by each athlete.
        - We would need to know the distance covered by each athlete for each step.
        - We would have to assume that the distance covered for each step will remain constant.
        - We would need to know the number of steps taken per unit of time (ex: 4 steps per second) AND we would need to know if this remains constant or not.

Take note of student responses while ensuring that the perspectives and voices of all students have been heard and valued before moving to the Action.

Action (80 Minutes)

Represent a well-known situation

Ask students if it would be possible to mathematically represent the 150-m race between Donovan Bailey and Michael Johnson. Answers may vary, but teacher questioning should direct students to the idea that a race could be represented with a table of values and a graph. Ensure that students recognize that when we represent a relationship with a table of values or a graph, we need to define two variables that are related. There are several possible variables to compare in this situation. The teacher's questioning should direct students to consider time as the independent variable, and the number of steps taken as the dependent variable. Remember that the purpose of this first step is simply to represent mathematically what happened in the race.

Possible teacher prompts: Where on our graph should we place our variables? Will time go on the x- or y-axis? Why is time normally on the x-axis (the independent variable)? Are there situations where time could be on the y-axis (dependent variable)? (This last question should be asked only if the group is ready for such a conversation, and could also be asked later.)

Place the students in teams of two using visibly random grouping or strategic grouping. As a team, students will represent the race between Donovan Bailey and Michael Johnson with a table of values and a graph.

Have the students watch the video again to try to retrieve data by watching the two runners. An assumption will have to be made for any information that cannot be observed.

Students can use materials such as stopwatches and graph paper to help them model the race.

Here is an example of the situation:

- Observations:
  - The distance traveled is 150 m.
  - Both athletes run at almost the same speed at the start of the race.
  - At around 9 seconds (on the stopwatch on the screen), the athlete on the outside track, Michael Johnson, slows down drastically.
  - The athlete on the inside track, Donovan Bailey, completes the race in exactly 15 seconds.
- Assumptions:
  - Both athletes will have the same number of steps until 9 seconds
  - The inside athlete, Donovan Bailey, maintains the same pace (steps per second) throughout the race.
  - The outside athlete, Michael Johnson, has two different step lengths, one during the first 9 seconds and a second that starts after 9 seconds.
  - Looking at the video, we believe that both athletes start with a pace of 5 steps per second. When Michael Johnson slows down, his pace is 3 steps per second.

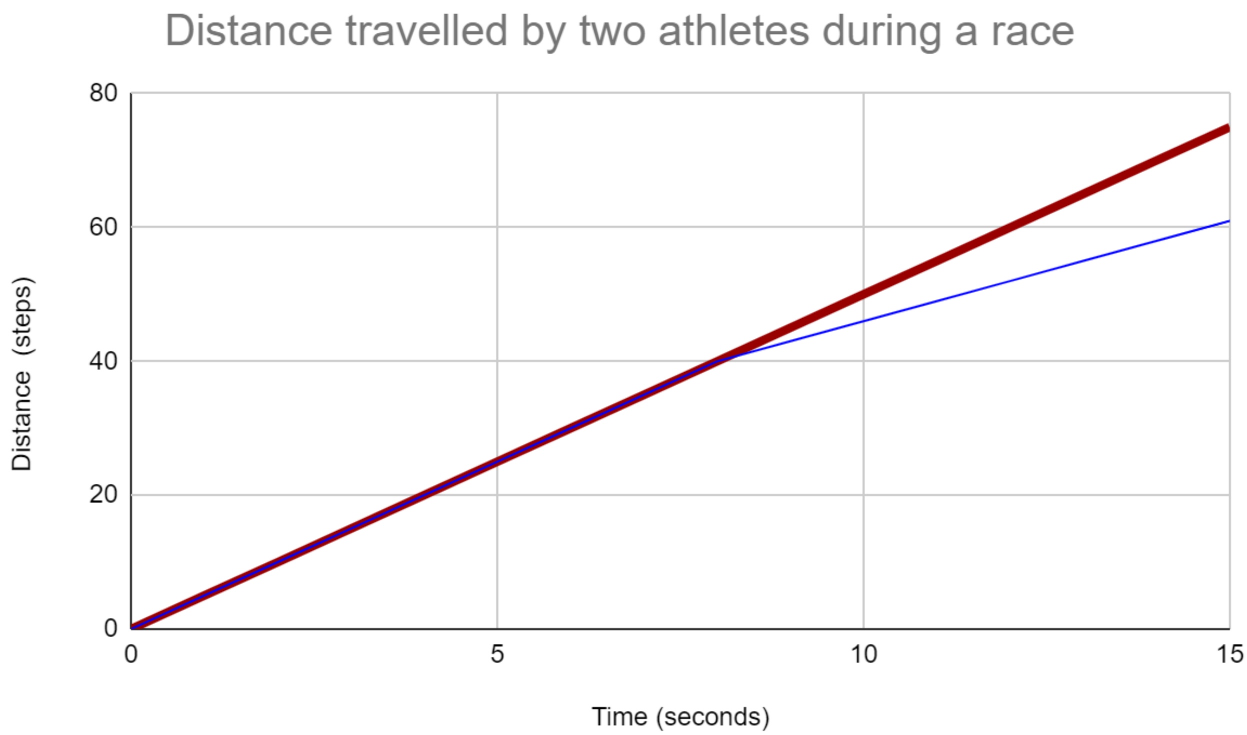
There are several ways to represent this situation. A team could, for example, divide the distance of 150 m by the time of 15 s to get a speed in metres per second, and then estimate the number of steps needed to travel 10 m, which would give the number of steps per second. Another team could closely count the steps of each athlete, one at a time over a set period of time, to identify an average number of steps per second, and then transfer the information to their graph. In this case, the assumption would be that the number of steps per second (rate) remains constant.

Here is an example of a representation of the situation using the number of steps as the dependent variable. At least one group will need to use the number of steps and time to represent the situation in order for the remainder of the lesson to flow.

Table of values

Time	Number of steps	
	Outside athlete (red track)	Inside athlete (blue track)
0	0	0
1	5	5
2	10	10
3	15	15
4	20	20
5	25	25
6	30	30
7	35	35
8	40	40
9	45	43
10	50	46
11	55	49
12	60	52
13	63	55
14	70	58
15	75	61

Graph



When the teams have finished creating their table of values and graph, students should return to the large group for consolidation. Select teams to share their strategies, observations and assumptions with the class. Make a strategic selection so that different approaches and different assumptions are brought to light.

Watching the video, we see that Michael Johnson did not finish the race. Given that information, ask students if it would be possible to predict the time it would take for him to have completed the race if he had continued at the same pace. How can we do it? Is there more than one way? Students can then return to their teams, select a strategy, and apply it to determine the time it would have taken for Michael Johnson to cross the finish line.

Ask the teams if it would be possible to represent the trajectory of one of the two athletes with an equation in the form $y = ax + b$. What would "a" represent? What would "b" represent? (Since the graph represents the number of steps per second, the rate of change, "a," would be the number of steps, and the initial value, "b," would be the number of steps taken at the beginning of the athlete's run.)

Lead a sharing discussion:

Ask teams to share their answers. Then ask teams "What are reasonable values for 'a' and 'b'?"

Next, ask students what it means if the value of "b" was not zero. Are there racing situations where the value of "b" is not zero? Example: In a 4 X 100 m relay race, the first runner would start with a value of "b" that would be 0, but the 2nd, 3rd and 4th runners continue the race with some distance already covered. Therefore, if we represent the distance of the runner in relation to the total distance of the race, the value of "b" would not be 0.

Running toward the unknown

Note: Throughout this next sequence, the teacher should walk around and take observations of student learning using the suggested tracking tool.

Now that students have practiced representing a step-based race situation, they can apply their knowledge to determine who will win a fictitious race without even running it!

First, you have to determine the distance that will be covered.

- You can use an outdoor athletic track, soccer field, or create your own track inside the school. You can also use common race distances (eg: 5 km, 10 km, half-marathon, etc.). The total distance must be known.
- Identify an indoor or outdoor space where you can have students run a distance of 10 meters. Note: Respect your school's health and safety standards. A gymnasium or outdoor track would be ideal, but if that is not possible, a flat, uncluttered area would be appropriate.

In order to make data collection and representation a little less cumbersome, students can be in small groups (4-5) for data collection and representation. Students can use this data collection tool, or a tool of their own design.

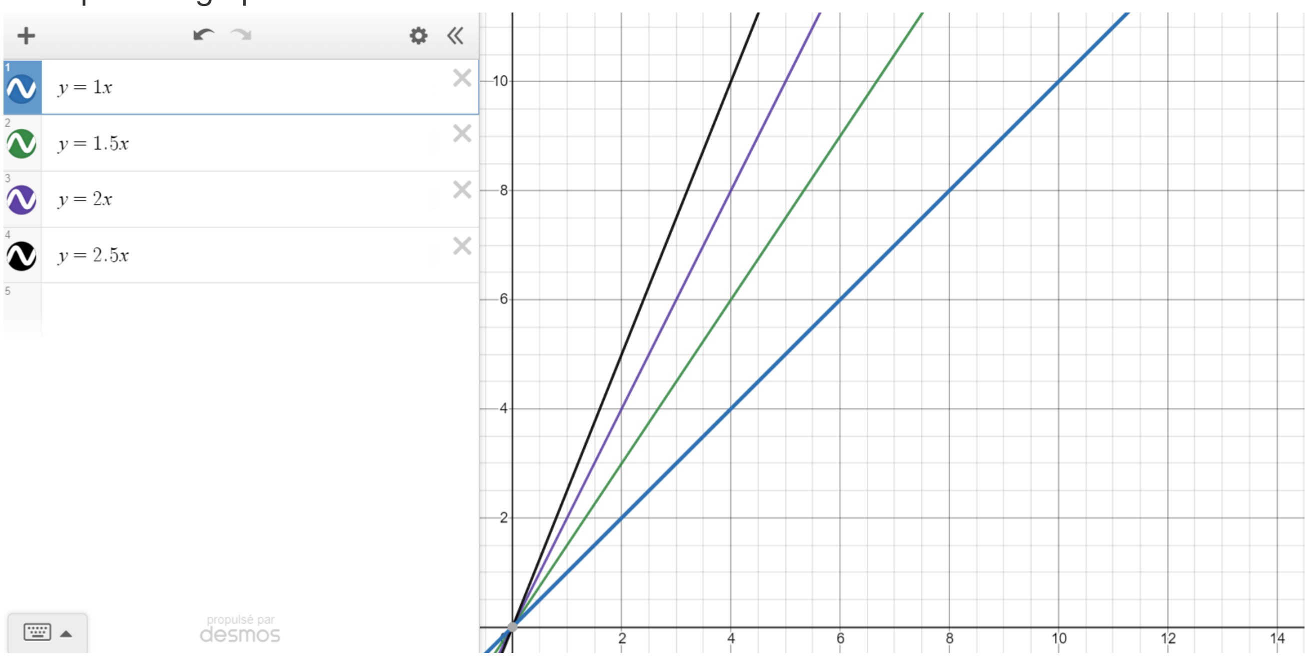
Each student will run the 10-metre distance while a second member of the group counts the runner's steps and a third member tracks the time. This should be repeated 3 - 5 times for each student. Then, bring the students back to the large group and ask them what data would be used to model the students' number of steps per second.

Anticipated responses:

- the mean
- the mode
- the fastest try
- the slowest try

Discuss the pros and cons for each method before choosing one for the whole class. Respecting the method chosen by the group, the students will have to determine a number of steps and a time for their 10 m journey. Students will now need to determine their number of steps per second, the rate of change, which will then be placed in the equation of the line that was determined earlier. Finally, using graphing software such as Desmos or Sheets, students will represent the different possibilities. Encourage them to use their actual values, which could be decimals.

Example of a graph:



Possible questions after the graphical representation:

- What do the lines of this graph mean? How do you know?
- Can the model effectively predict who would win the x km race (return to the distance decided together at the start of the activity)? How can we improve the model?
- If we had chosen a different way of handling our data (mode, average, fastest test, etc.), would the result change? What conclusions can we draw in relation to this situation?

- Does a distance of 10m allow us to effectively predict a person's performance over a greater distance? What factors have we not considered?
- Is counting steps an effective way to determine distance traveled? How could we be more precise?

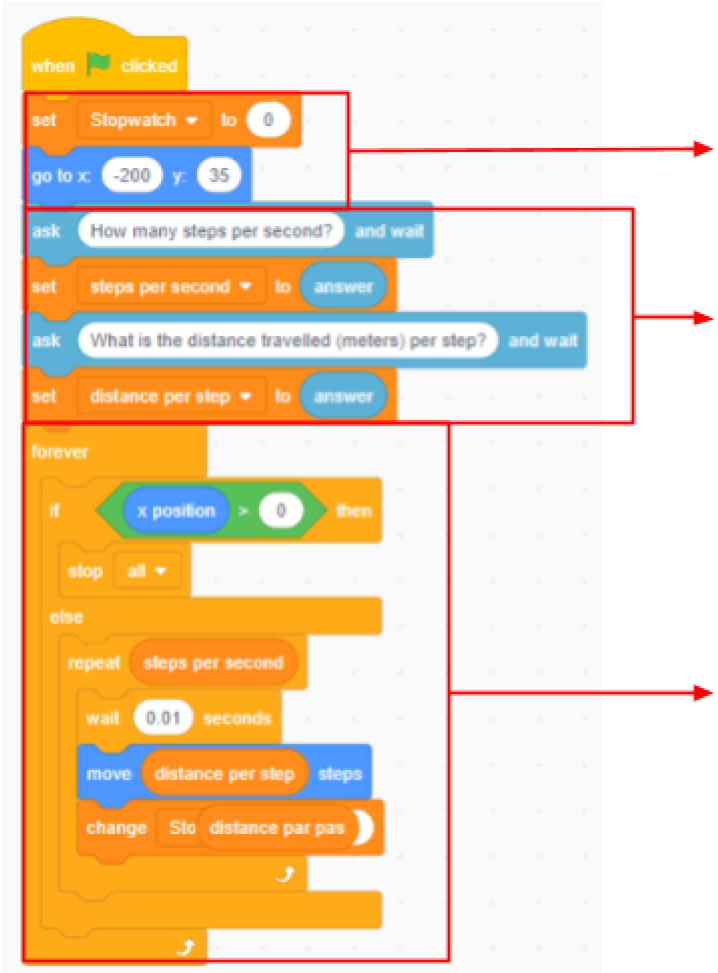
Students should consider these questions individually at first, followed by sharing in small groups, and finally consolidating as a large group, to ensure that students have understood the purpose of the activity.

Make Predictions

Using a block-based, or more advanced text-based coding software, students will create an algorithm that determines the number of steps required to travel a known distance.

As a class or small group, using pseudo-code, work out what you want your algorithm to do, step by step. (Pseudo-code is a way of representing the actions that we want to perform in regular language, allowing us to better understand our plan when we move to coding software.)

Here, we use Scratch software to create the code. Note that it is possible to use a variety of coding software, and an example is provided in the "Possible extensions" section. In our example, we are going to move the sprite, the Scratch cat, according to a set of specific instructions.
We have chosen the 30px grid for the example, but students can use a more fun background if desired. Here is a sample code:



These two blocks represent the initial starting point for our code. The coordinates could vary based on the initial position of the sprite

These blocks allow for students to collect values for their two variables, steps per second and distance per step.

Here, we are asking the program to add one second to the stopwatch as the sprite moves forward a number of steps as defined by the steps per second variable, until it reaches the end point (x = 0).

This allows students to determine the theoretical winner of the race, the person who completes the course in the shortest amount of time according to the stopwatch!

You can also REMIX this code!

Sample micro:bit code

We see that the code allows us to control two variables. This will allow the student to compare different runners having the same number of steps per second but whose step length varies, and opposite situations where the step lengths are the same but the number of steps per second are different. This will "break the tie" between students who may have “steps per second” rates that are the same, but where one student takes longer steps than the other. There is also a stopwatch to track time in seconds, but since one step is equal to one pixel in Scratch, the time interval used is 0.01 seconds to make the time more realistic.

This is only one example of code that would represent the situation, but students’ codes could vary.

The students will now have to return to their teams with whom they collected the data. Using the code, students will have to simulate the race for all team members to determine which student wins. The students will have to take note of the time (indicated by the stopwatch), and the student with the shortest time wins: theoretically! Then the groups can discuss the realism of the simulation and the validity of the results.

Possible questioning:

- Is there one variable that is more important than the other in this code? What information do you base your answer on?
- In what other types of situations might this sort of comparison be important?
- Can we now effectively determine who would win our classroom race? What information are we missing? What assumptions do we have to make to determine the winner?

Answers may vary, but the purpose of the questioning is to have the students realize that, despite the fact that we have modeled the situation well for a 10m run, the data cannot be applied for a longer run because we neglected several elements such as training, endurance, race track conditions, weather conditions, etc.

Extension Opportunities

Accelerometer Coding

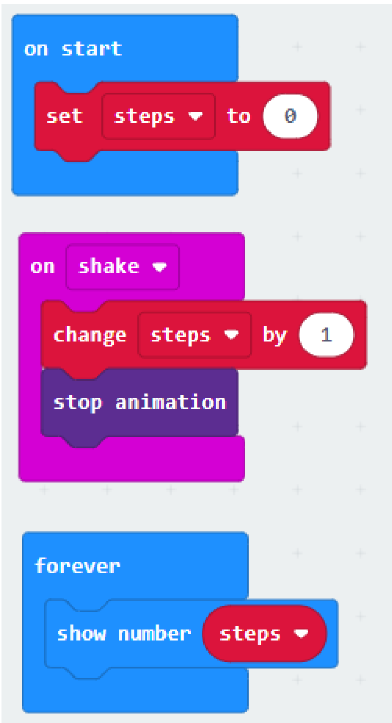
To go further, the teacher might ask students if there is a more efficient way to count steps using technology. Students will take out their cell phone, Fitbit, Apple watch, or other technologies that count steps. The teacher now suggests creating a code to create a step counter. Students will be able to create and program a step counter with microcomputers (e.g. micro:bit, Arduino, Raspberry Pi, littleBits, etc.). The example provided below uses the micro:bit, but other microcomputers will follow the same steps.

How it works

The step counter code will use an accelerometer to do an action when it is shaken. It will count how many times the accelerometer has been shaken. This number is stored in a variable called 'step'. The variables are used to store information that can change, such as the number of steps. Each time the accelerometer shakes, the program increases the variable by 1, and displays the new number on its screen.

In a small group, give students time to explore the features of the micro:bit and determine that the accelerometer would be the best feature for the step counter. In a whole class group or in small groups, students create pseudo code to establish what they want their step counter to do step by step.

- To do the programming of the micro: bit, students can use the site https://makecode.microbit.org/#editor. to create the code. Code can be created in block, JavaScript or Python depending on your board's preferences and the skills of your students. In order to achieve this, time will have to be allocated for the coding.
    - Here is a possible answer: https://makecode.microbit.org/#pub:_E6uhUWKEqL1L&lang=en
    - Here is another idea:



Consolidation (20 Minutes)

In the next part, we want students to realize that the way we choose to represent and interpret data will affect the results.

Ask students again if the number of steps is a good way to measure distance. Lead the discussion by talking about apps like Apple Health and Google Fit and devices like pedometers, fitbits, etc. Are the data collected by these devices reliable? How do you know? How can we make the data collected by this type of device more reliable? Possible answers:

- A GPS would be more precise in determining the distance traveled.
- If the number of steps is used, it would also be necessary to know the height of the person (link to the lesson A Big Shoe to Fill).
- Ask the students again if a change during the data analysis (average, mode, fastest race, etc.) would have had an effect on the results.

Possible prompting questions:

- How can we decide the best way to analyse data? Do we have any real life applications that could help us decide?
- How could we have improved the accuracy of the results? What mistakes could have been made?
- Are there any biases that occurred during your data collection? How could they have been avoided?

Distribute the exit ticket. The question can be modified according to the interests of the students. The students could either hand in the exit ticket as evidence of learning, or a debate-style conversation could be organized between the different positions related to the question on the ticket.

Appendix 1: Observation/Conversation Tracking Chart

C	**C**ommunicates effectively their thoughts and uses correct vocabulary
J	**J**ustifies their point of view and assumptions
R	Uses **r**epresentations (graphics, table of values, formulas, block code) effectively
V	**V**erifies determines whether the results obtained by the simulation are realistic

Date ⇢ **Names** ↓					
	CJRV	CJRV	CJRV	CJRV	CJRV
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	CJRV	CJRV	CJRV	CJRV	CJRV
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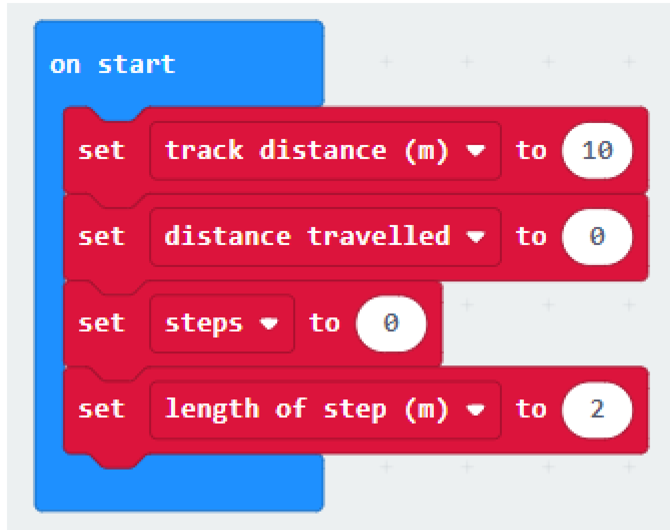
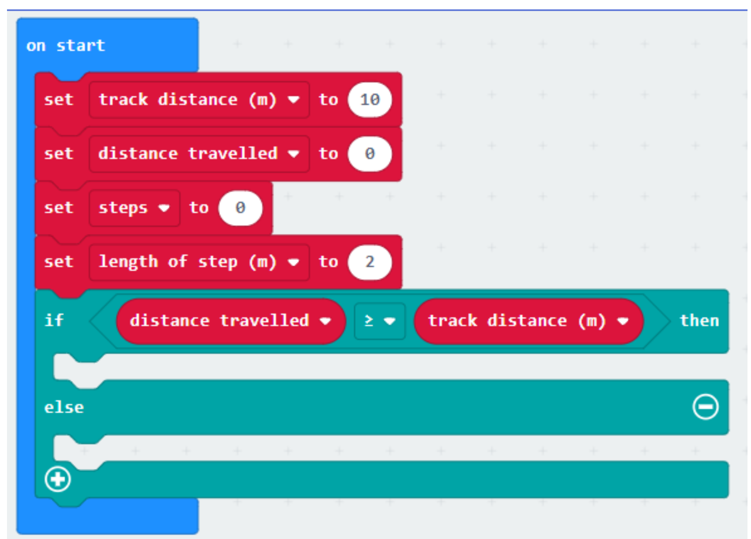
	CJRV	CJRV	CJRV	CJRV	CJRV
	CJRV	CJRV	CJRV	CJRV	CJRV

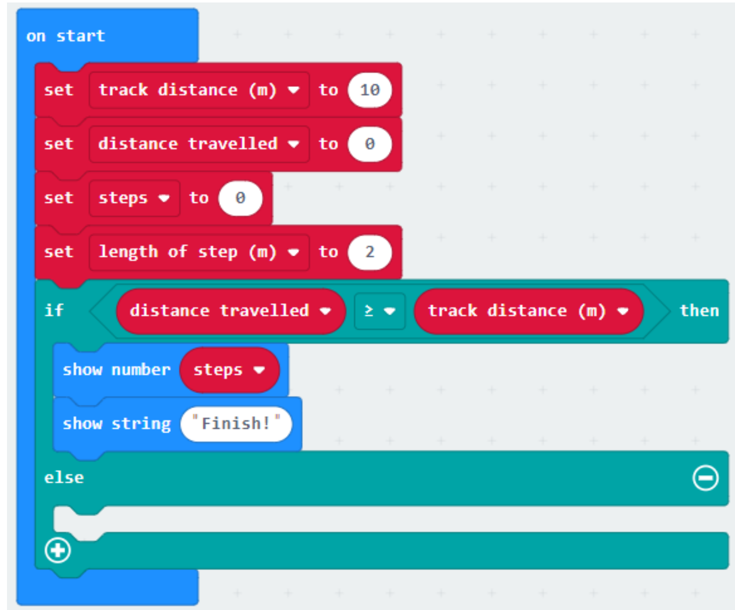
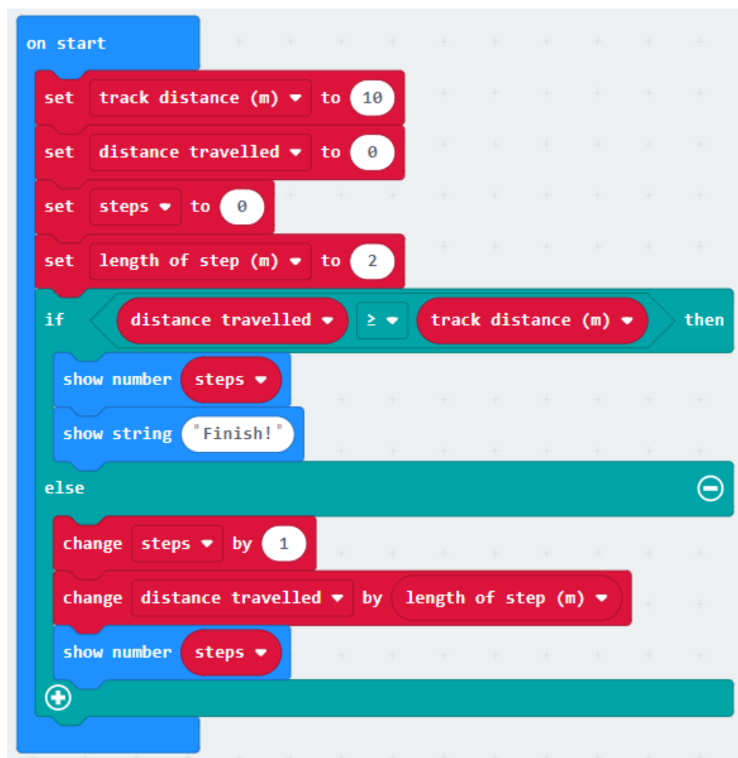
O ⇨ criterion acquired criterion / ⇨ semi-acquired criterion X ⇨ non-acquired criterion

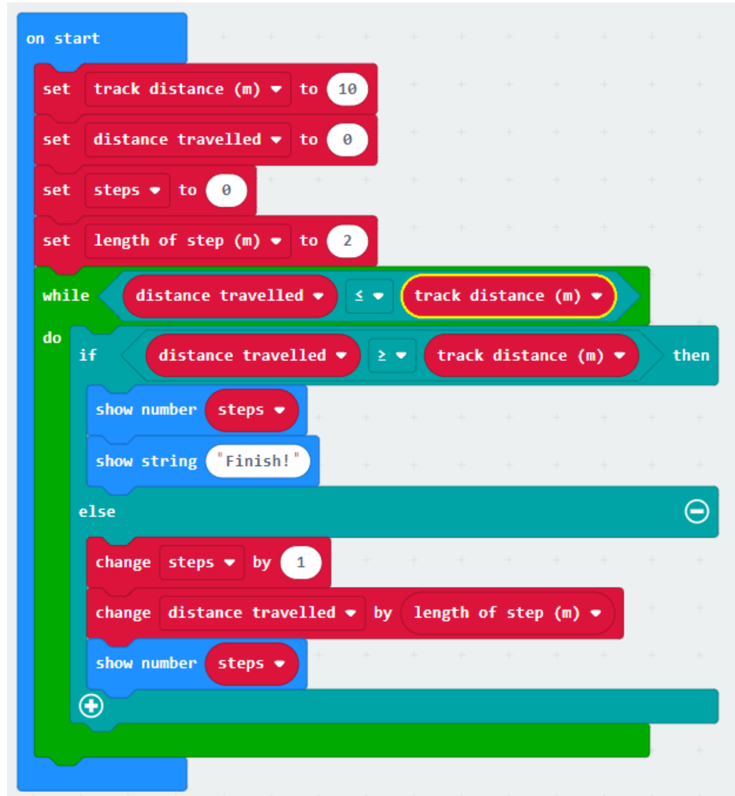
Appendix 2: Data Collection

Student Name	Test 1		Test 2		Test 3	
	# Steps	Time (s)	# Steps	Time (s)	# Steps	Time (s)

Appendix 3 Sample micro:bit code

1	**Creating the variables**	
2	**The goal**	

<table>
<tr>
<td>3</td>
<td>The outcome, if achieved</td>
<td>
</td>
</tr>
<tr>
<td>4</td>
<td>If not, I have to keep going</td>
<td>
</td>
</tr>
</table>

5	**Repeat**	on start
		set track distance (m) to 10
		set distance travelled to 0
		set steps to 0
		set length of step (m) to 2
		while distance travelled ≤ track distance (m)
		do
		if distance travelled ≥ track distance (m) then
		show number steps
		show string "Finish!"
		else
		change steps by 1
		change distance travelled by length of step (m)
		show number steps

Appendix 4 Exit ticket

Name: ______________________________

Date: ______________________________

Period / Goal: ______________________

During a baseball tryout, the coach counts the number of steps of the athletes running to first base to determine who will make the team. Do you agree with this method of choosing team members? Explain your reasoning using what you learned today.

Name: ______________________________

Date: ______________________________

Period / Goal: ______________________

During a baseball tryout, the coach counts the number of steps of the athletes running to first base to determine who will make the team. Do you agree with this method of choosing team members? Explain your reasoning using what you learned today.