LOOPS Teacher's Manual

In the Concord Consortium LOOPS field-test, you will be teaching four related activities about motion and graphing that are described below. We have worked hard to improve the activities and the software system that they run on over previous field trials so that students and teachers find them engaging, easy to use, and well suited to the learning goals. However, the LOOPS project is not just a curriculum and technology development project. It is also a research project that seeks to clarify ideas about how technology may best be applied to classroom teaching and learning. Our main research question is: If teachers have instantaneous access to students' on-going work through the use of technology, how best can that information be used? We have developed this manual to help you in understanding the goals of the curriculum and using the technology. We also want to provide some insight into "the experiment" that forms the heart of our research and your role in it.

Overview of Research:

Our research goal is to test different teaching patterns using the formative assessment within the LOOPS system. Therefore, we will be asking you to teach somewhat differently in your different classes. Specifically, we want to compare the use of frequent class discussions based on students' submitted work, tied closely in time to the learning activities, to a pattern where all-class discussions are confined to the start of the class period, leaving more time for students to work individually and teachers to assist students individually.

To run this experiment, you will be acting as your own control. Half of your classes will follow the experimental protocol and half of your classes will follow the control protocol. For our research to be effective, it is very important that you adhere to the research protocol for the experimental and control classes. We do realize that this may be challenging as it may push you out of your most accustomed classroom habits. However, we believe that it will be a beneficial learning experience for us all. The table below is an example of the different patterns we hope to assess in this experiment.

Day	Control	Experiment
1	Full-Class Introduction Students work in groups – teacher follows work on tablets and provides individual instruction.	Full-Class Introduction Students work in groups – teacher follows work on tablets with periodic full-class discussions using student work.
2	Full-Class discussion using student work and introduction of new material. Students work in groups – teacher follows work on tablets and provides individual instruction.	Full-Class discussion using student work and introduction of new material. Students work in groups – teacher follows work on tablets with periodic full-class discussions using student work.
Etc.		

In this manual, we have articulated the curriculum's learning goals and have indicated places where you can have discussions with your classes designed to achieve these goals. You are free to discuss other questions with your students in addition to the "required" discussions. However, the discussions in your control classes should be limited to the questions that you have discussed in your experimental classes, so that the discussion topics remain the same across both control and experimental classes.

Overview of Activities

These are inquiry activities. Although many definitions of inquiry activities exist, we define our inquiry activities as ones where students discover their own answers. Whenever possible, you should try not to answer your students' questions directly, but rather encourage them to devise experiments to find the answers. We wish to build students' confidence in their ability to discover their own answers.

In the first activity (**Missing Manual**), students explore qualitative aspects of graphing and motion. Using a motion probe students observe the correspondence between the shape of the curve on a position versus time graph and the kinesthetic motion of their bodies that created it. Learning goals are for students to relate the slope of the line to the speed and direction of their motion and the height of the line to their position in front of the probe.

In the second activity (**Modeling Motion**), students explore motion by manipulating a model that is tied to a graph, and also the reverse of this, namely drawing a graph to move a model. This begins the transition from a qualitative description of motion to a quantitative one. Here they begin to understand that graphs tell stories and that motion takes place in a frame of reference. They start to relate positions to actual locations and their numeric representation, explaining what a position-time graph represents. Finally, they start quantitatively comparing speeds by seeing how much distance is covered in a given interval of time.

In the third activity (**Making Measurements**), students return to using the motion probe. This activity emphasizes quantitative measurements made from the graphs of their body motion. After practicing making measurements of distance and duration, students use those skills to calculate speed. Students also formally capture their understanding of the frame of reference by drawing the number line defined by the probe, locating a picture of the probe on it.

In the final activity (**Telling Stories**), students practice interpreting graphs to elucidate the stories being told and drawing graphs from stories. They further practice their ability to turn slopes on graphs into calculated speeds and vice versa.

Learning Goals and Discussion Topics by Activity

Color Code for Activities described in the pages that follow:

Missing Manual
Modeling Motion
Making Measurements
Telling Stories

Missing Manual

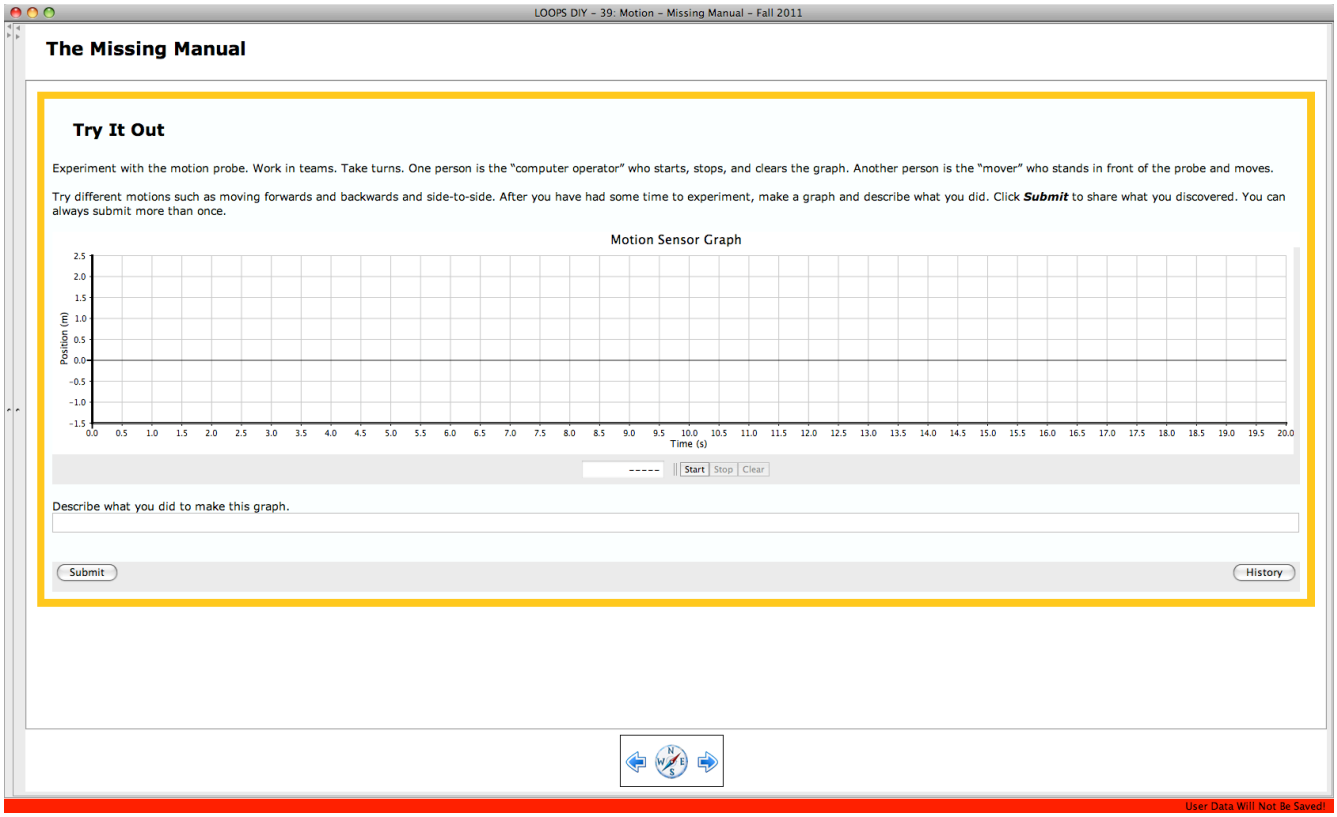
Learning Goals:

1. Be able to interpret graphs of position vs. time and describe qualitatively
    a) position is represented on the y-axis
    b) time is represented on the x-axis
    c) positive slope and negative slope relate to direction
    d) steepness of slope relates to speed
    e) duration can be measured on the x-axis
    f) distance can be measured on the y-axis

2. Be able to create and interpret a number line/graph based on a frame of reference. Positions may be on a number line that may include negative numbers.

Try It Out

In this step, students learn about the motion probe. They make a graph of their motion and explain how they moved to make the lines on the graph.



This is an opportunity to set expectations for students' work. It is not enough for the students to state that they "moved backwards and forwards." They should be looking at their movement and the line on the graph in conjunction; they should be able to define where on the graph they were moving toward the probe and away from the probe.

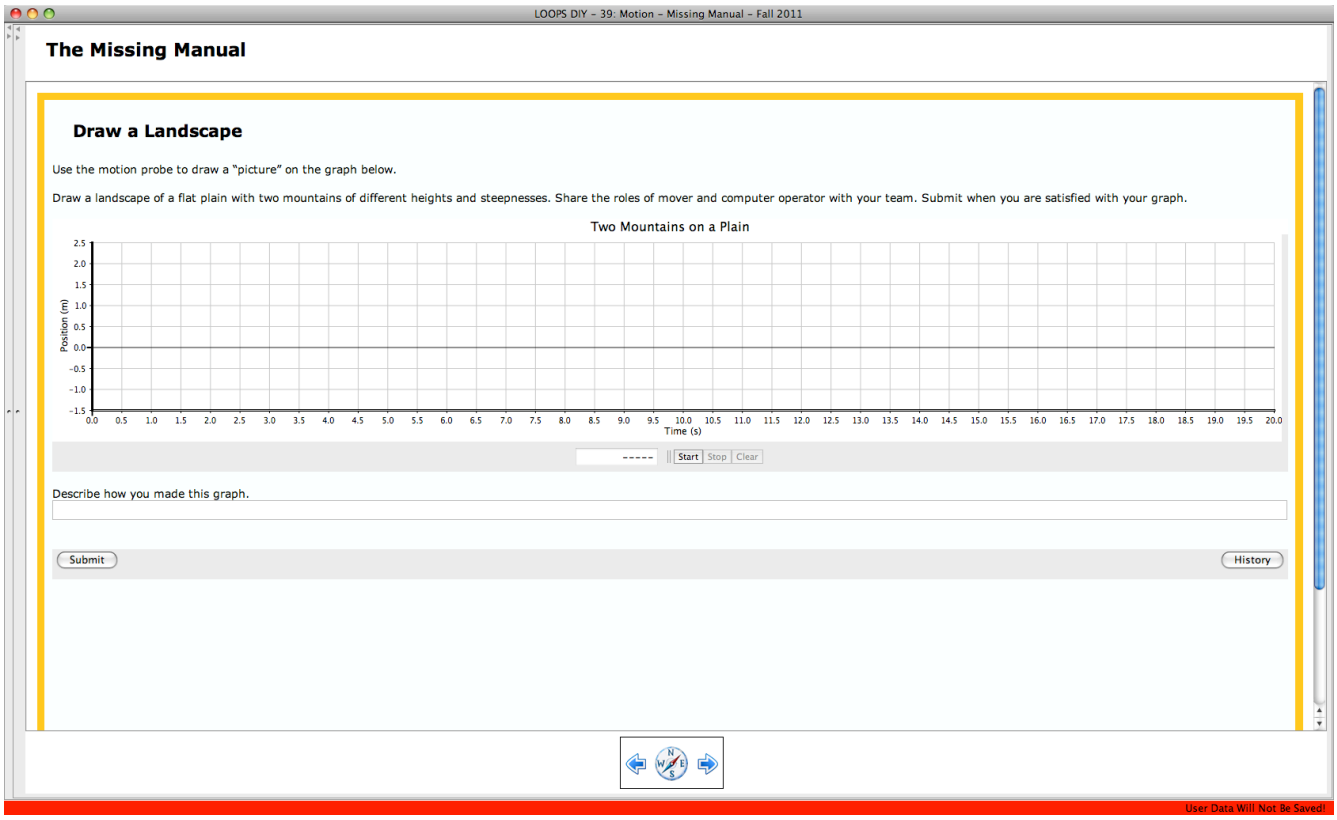
Does the description match the motion?

Things to Notice:

1) The slope of the line refers to the direction of movement and the speed of the movement.
2) Horizontal lines refer to no motion toward or away from the probe.
3) Some motions may not affect the line on the graph (sideways motions, up and down motions).
4) Focus on the qualitative aspects of the graph, not the quantitative aspects.

Draw a Landscape

In this step, students use the motion probe to make a landscape of two mountains on a plain, making qualitative observations about the shape produced. The mountains should be different heights and have different steepnesses.



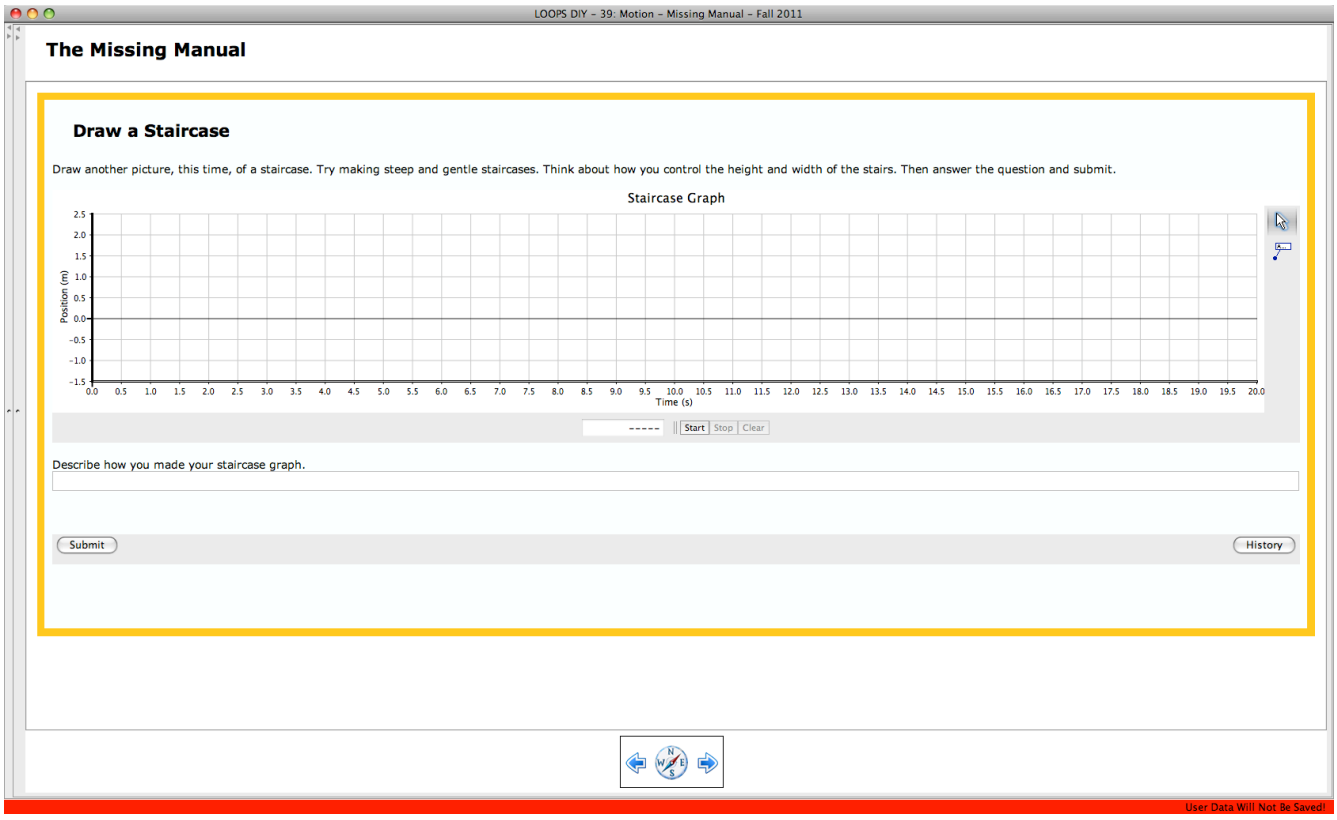
This activity is purposely qualitative in order to explore students' misconceptions about what lines on a position vs. time graph represent. Some students may think that the positive slope of the mountains is related to walking uphill, while the negative slope represents walking downhill. In reality, the motion that makes the mountain is the result of students walking away from the probe; the line represents the change in position rather than change in elevation.

Things to Notice:

1) Does the description match the motion?
2) Does the landscape meet the criteria (two mountains, different heights, different steepnesses, plain)?
3) How do you make a taller mountain?
4) How do you make a steeper (or more gentle-sloping) mountain?
5) Where do you stand to make the plain? (Different plains will be at different positions.)

Draw a Staircase

In this step, students use the motion probe to make a staircase. This is another purposely-qualitative exercise.



Things to Notice:

1) What motion controls the height of the riser (height of each step on the graph)?
2) What motion controls the length of the tread (horizontal portion of the step)?
3) Can you tell by looking at the graph how it was made? Which direction, how fast, how far were the motions?
4) What do the axes of the graph show? Start to look at the graph in a more quantitative manner.

Predict Your Motion

In this step, students write a procedure for the motions needed to match the provided graph.

This is a good place to remind your students that they need to be detailed in their procedures. Ideally, one student would write the procedure and the partner(s) would carry out the instructions exactly as they are written. Stress the importance of including as many details as possible to make the procedure very specific.

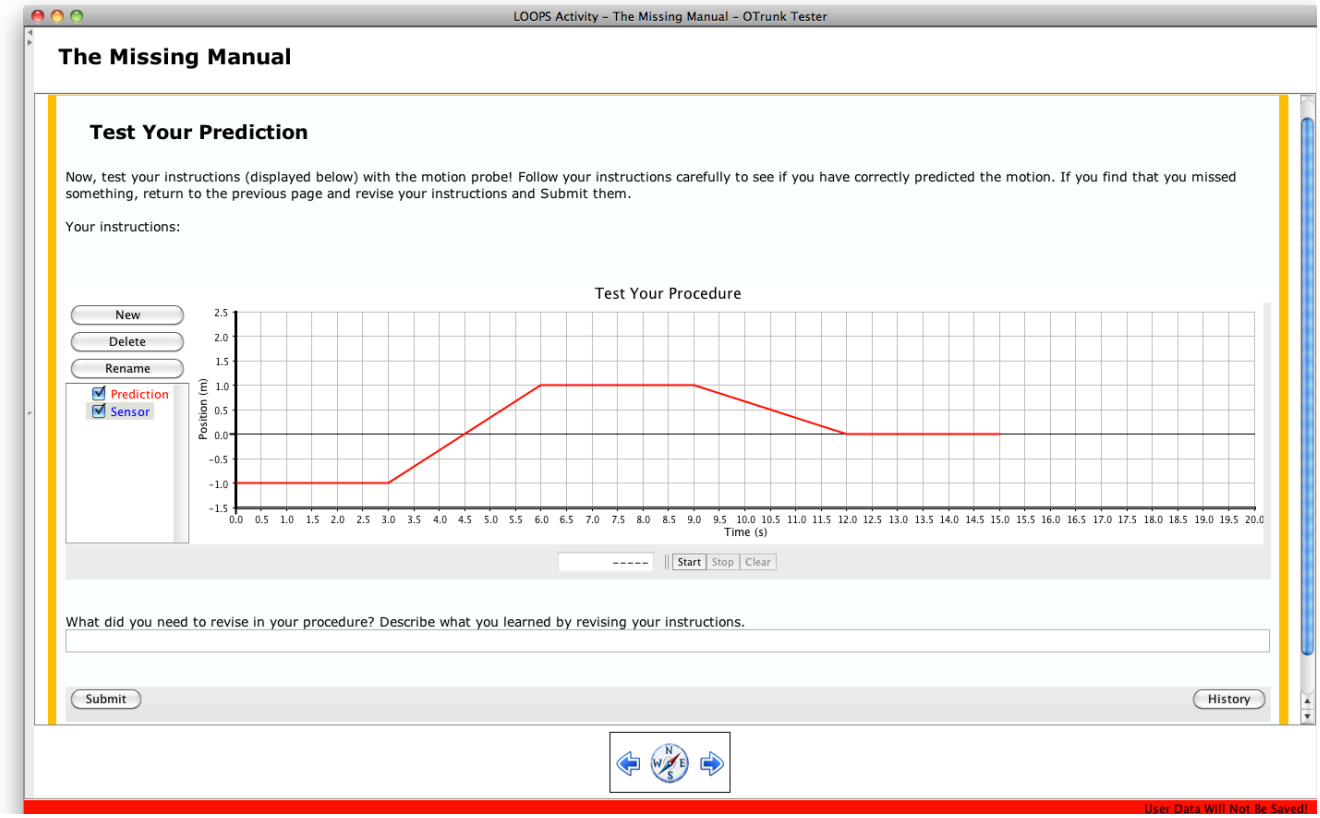
Things to Notice:

What do you need to describe in order to write a procedure that will produce a matching graph?

1. starting position
2. duration of motion
3. distance of motion
4. direction of motion
5. speed of motion (encompassed by 2,3, and 4)

Test Your Prediction

In this step, students check their procedure to see if it makes the same graph. Students are asked to reflect on what did not match and how their procedures should be changed to better match the provided graph.



Students' procedures will be shown in a non-mutable text box above the graph. The line that the students have to match will also be displayed on the "Test Your Procedure" graph.

Things to Notice:

1) Was the procedure detailed enough to accurately make the graph?
2) Was there enough information to follow? Did you skip any steps?

Modeling Motion

Learning Goals:

1. Be able to create and interpret a number line/graph based on a frame of reference. Positions may be on a number line that may include negative numbers.

2. Be able to interpret graphs of position vs. time and describe qualitatively
   a) position is represented on the y-axis
   b) time is represented on the x-axis
   c) positive slope and negative slope relate to direction
   d) steepness of slope relates to speed
   e) duration can be measured on the x-axis
   f) distance can be measured on the y-axis

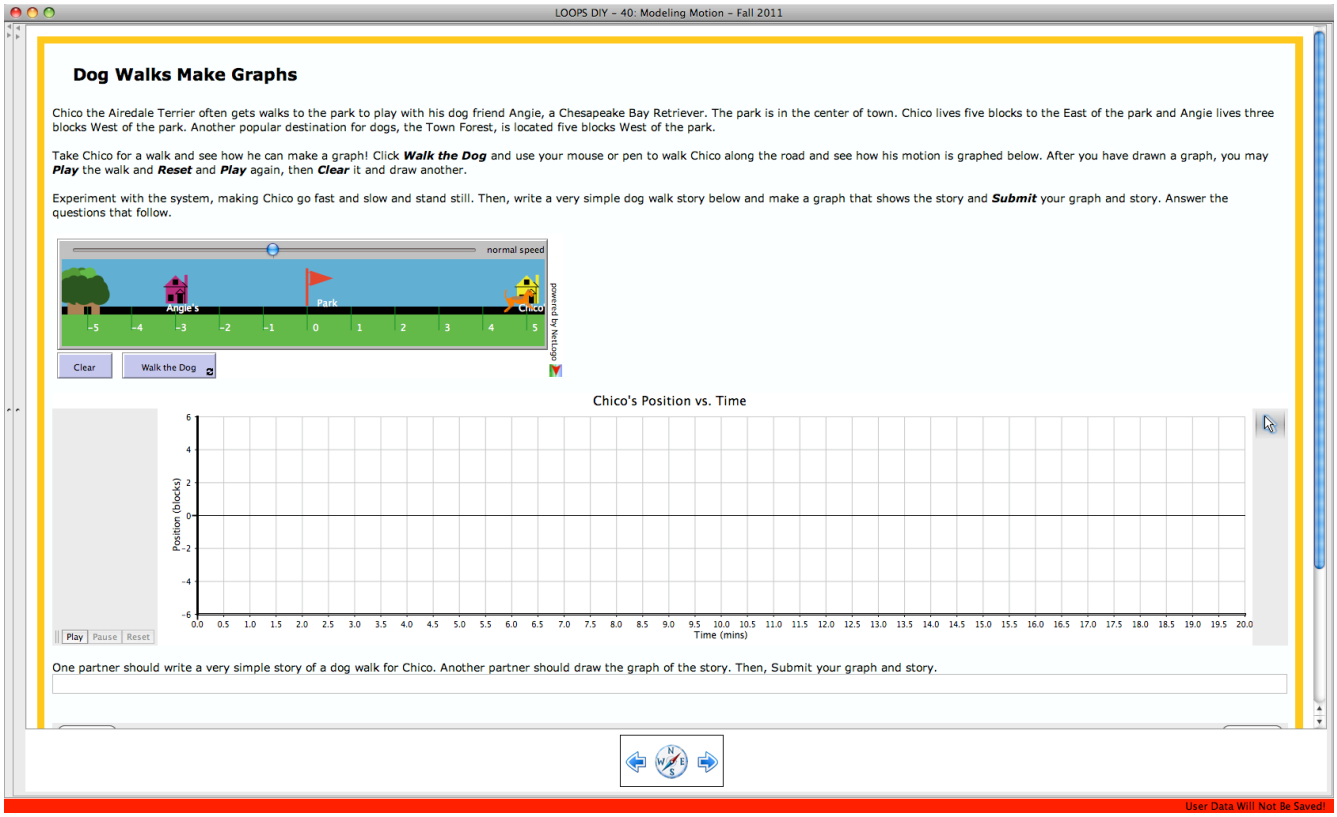
3. Be able to interpret graphs of position vs. time and describe quantitatively the motion represented
   a) measurements/calculations of distance between two positions
   b) measurements/calculations of duration between two events

4. Be able to create a graph of position vs. time that matches a motion story.

5. Be able to calculate velocity from a position vs time graph.

Dog Walks Make Graphs

In this step, students use a model to create a motion story.

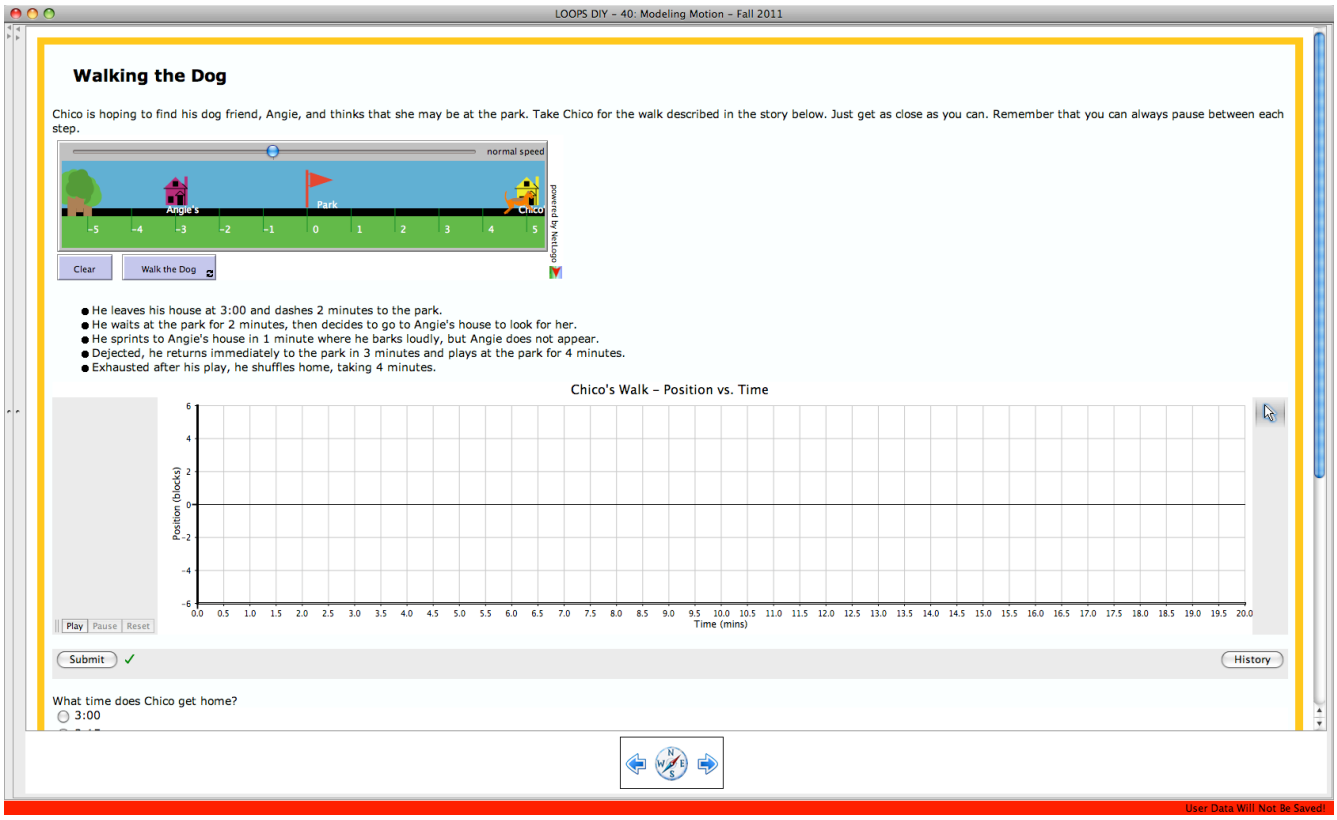


Things to Notice:

1) What information is necessary to make a motion story? (position, time, distance, speed)
2) Can you tell the motion in the story based only on the graph?

Walking the Dog

In this step, students use a model to create a graph based on a story.



Things to Notice:

1) How can you measure distances between positions on the model's number line and a graph?
2) How can you measure the duration of an event on a graph?
3) Use the multiple-choice item as a diagnostic to see how students have fared with calculating time.

   Distractor Analysis for what time Chico gets home:

   Choice 1: 3:00

   Students who choose this answer may not have read the introduction fully, thinking that 3:00 is the time Chico got home; 3:00 is the time that Chico left home.

   Choice 2: 3:15

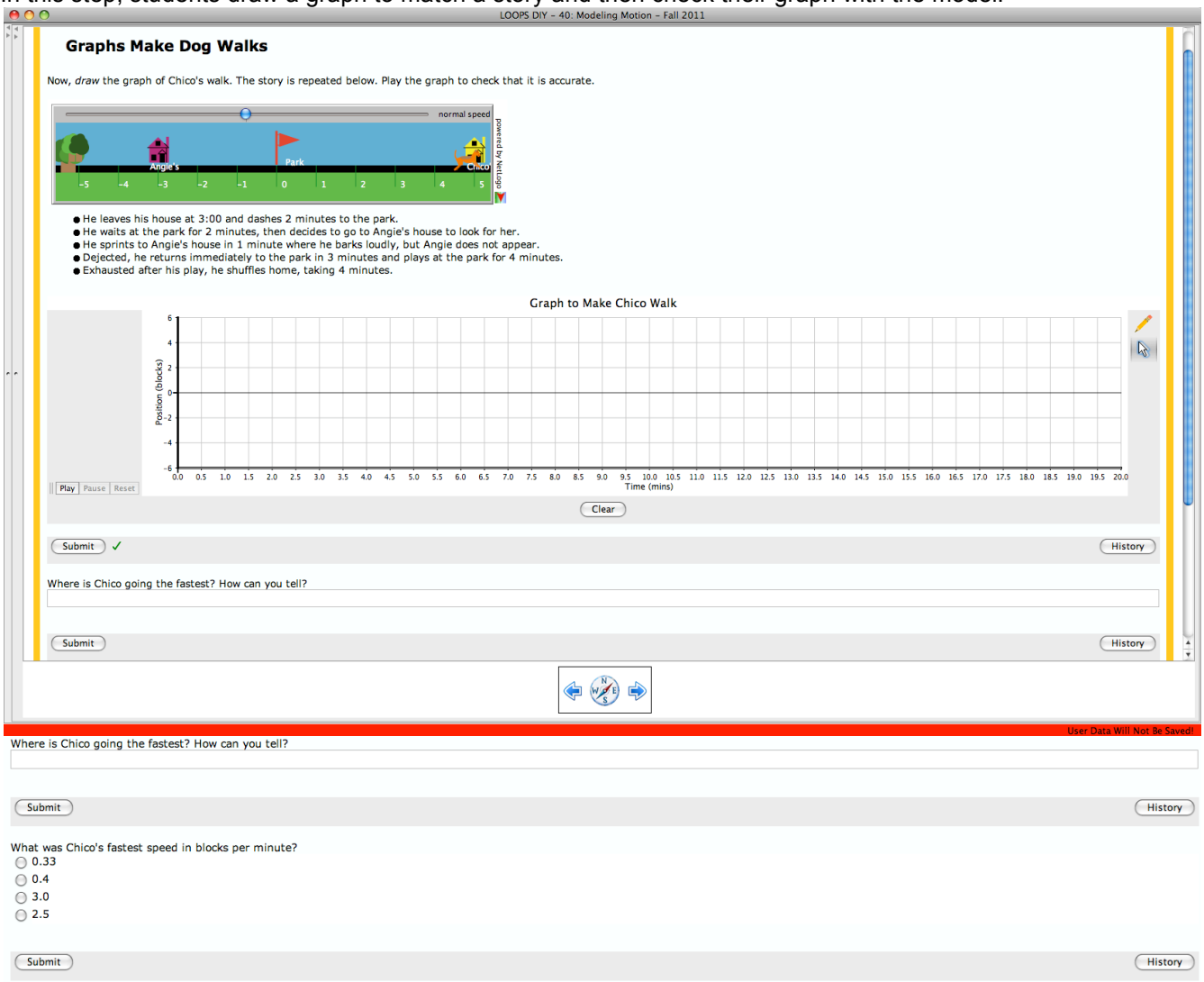
Students who choose this answer may have missed the time that Chico went to Angie's house.
Choice 3: 3:16
This is the correct answer.
Choice 4: Not enough information to tell.
Students who choose this answer may not have drawn the graph correctly from the story.

4) Use the multiple-choice item as a diagnostic to see how students have fared with calculating distance.

Distractor Analysis for distance between Chico's house and Angie's house:
Choice 1: 2 blocks
Students who choose this answer may be subtracting the numbers for the positions.
Choice 2: 7 blocks
Students who choose this answer may be miscounting the intervals between Chico's house and Angie's house.
Choice 3: -8 blocks
Students who choose this answer may think that the distance is negative since one of the positions is negative.
Choice 4: 8 blocks
This is the correct answer.

Graphs Make Dog Walks

In this step, students draw a graph to match a story and then check their graph with the model.



Things to Notice:

1) How can you measure speed on a graph?
2) How is speed calculated? What is speed?
3) Use the multiple-choice item as a diagnostic to see how students have fared with calculating speed.

Distractor Analysis for Chico's Speed:

Choice 1: 0.33 blocks/minute

Students who choose this answer have transposed the numbers in the speed formula, dividing time by distance rather than distance by time.

Choice 2: 0.4 blocks/minute

Students who choose this answer have chosen the wrong interval (when Chico is going from his house to the park) for the fastest speed as well as transposing the values for time and distance.

Choice 3: 3.0 blocks/minute

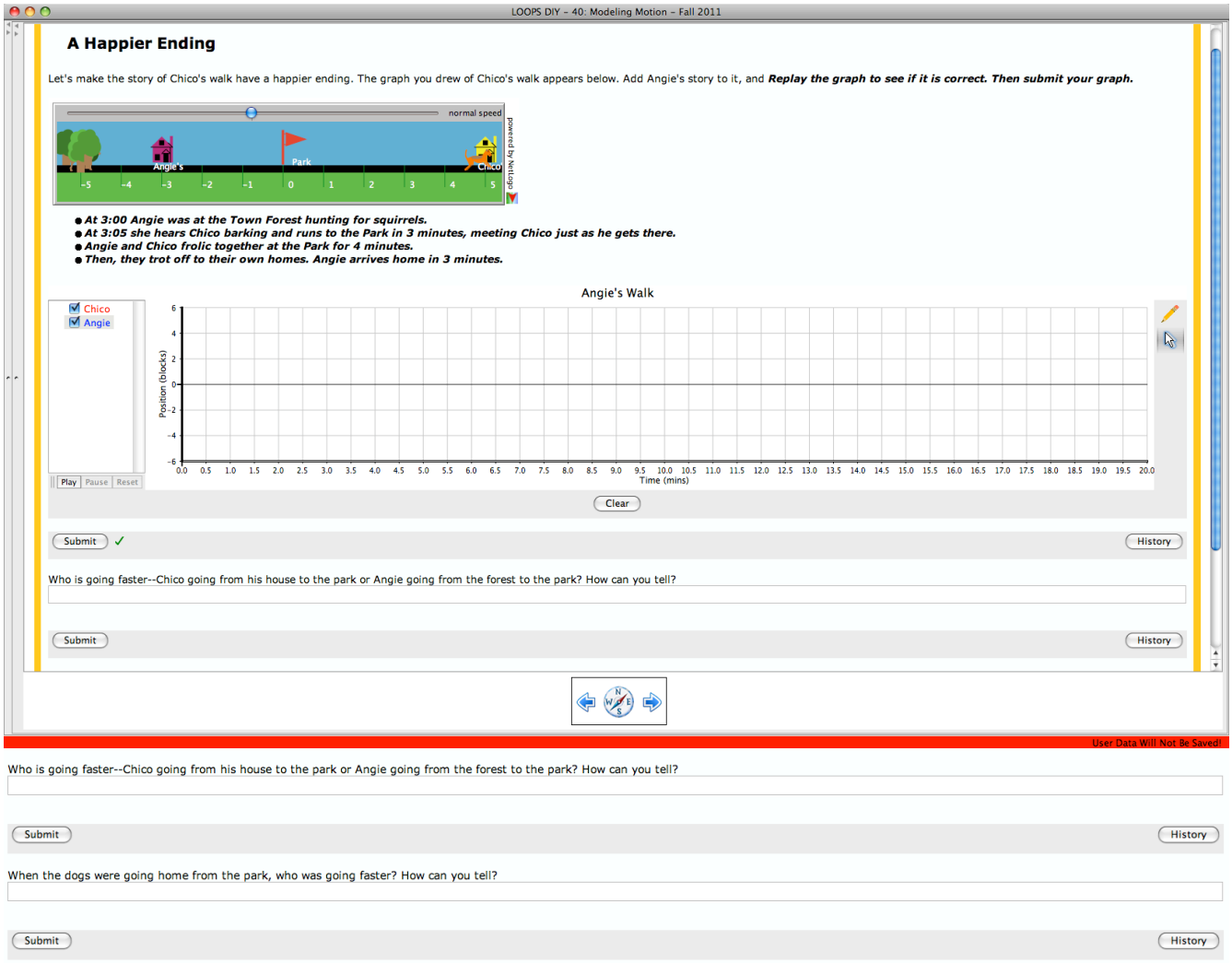
This is the correct answer. Students who choose this answer have recognized that Chico is moving the fastest when he goes from Angie's house to the park.

Choice 4: 2.5 blocks/minute

Students who choose this answer have chosen the wrong interval (when Chico is going from his house to the park) for the fastest speed.

A Happier Ending

In this step, students add another line to the graph to show the story of Angie's journey.



Things to Notice:

1) How can you tell from a graph which line indicates faster speed?
2) What if the directions of motion are opposite?

Making Measurements

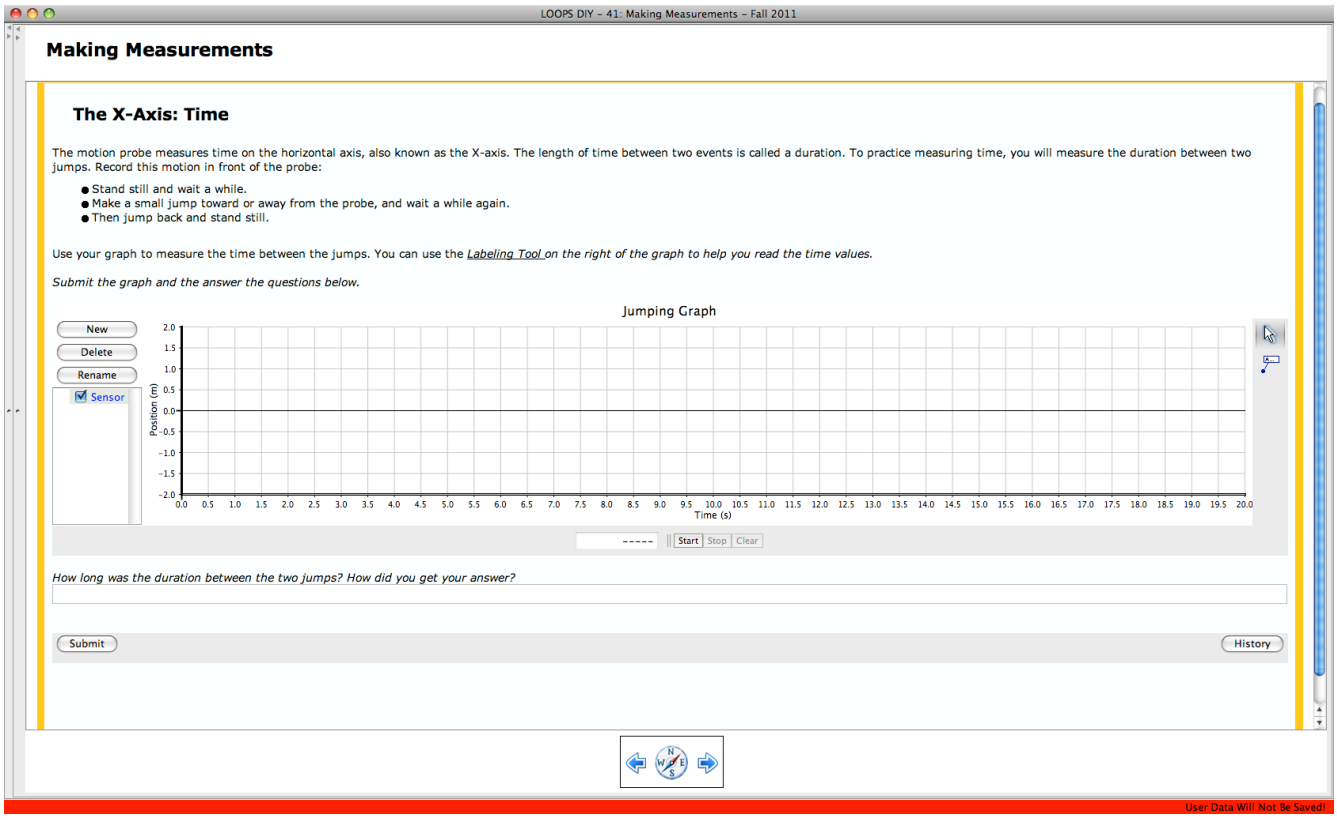
Learning Goals:
1. Be able to create and interpret a number line/graph based on a frame of reference. Positions may be on a number line that may include negative numbers.

2. Be able to interpret graphs of position vs. time and describe quantitatively the motion represented
   a) measurements/calculations of distance between two positions
   b) measurements/calculations of duration between two events

3. Be able to calculate velocity from a position vs time graph.

The X-Axis: Time

In this step, students use the x-axis to make measurements of the duration between two jumps.

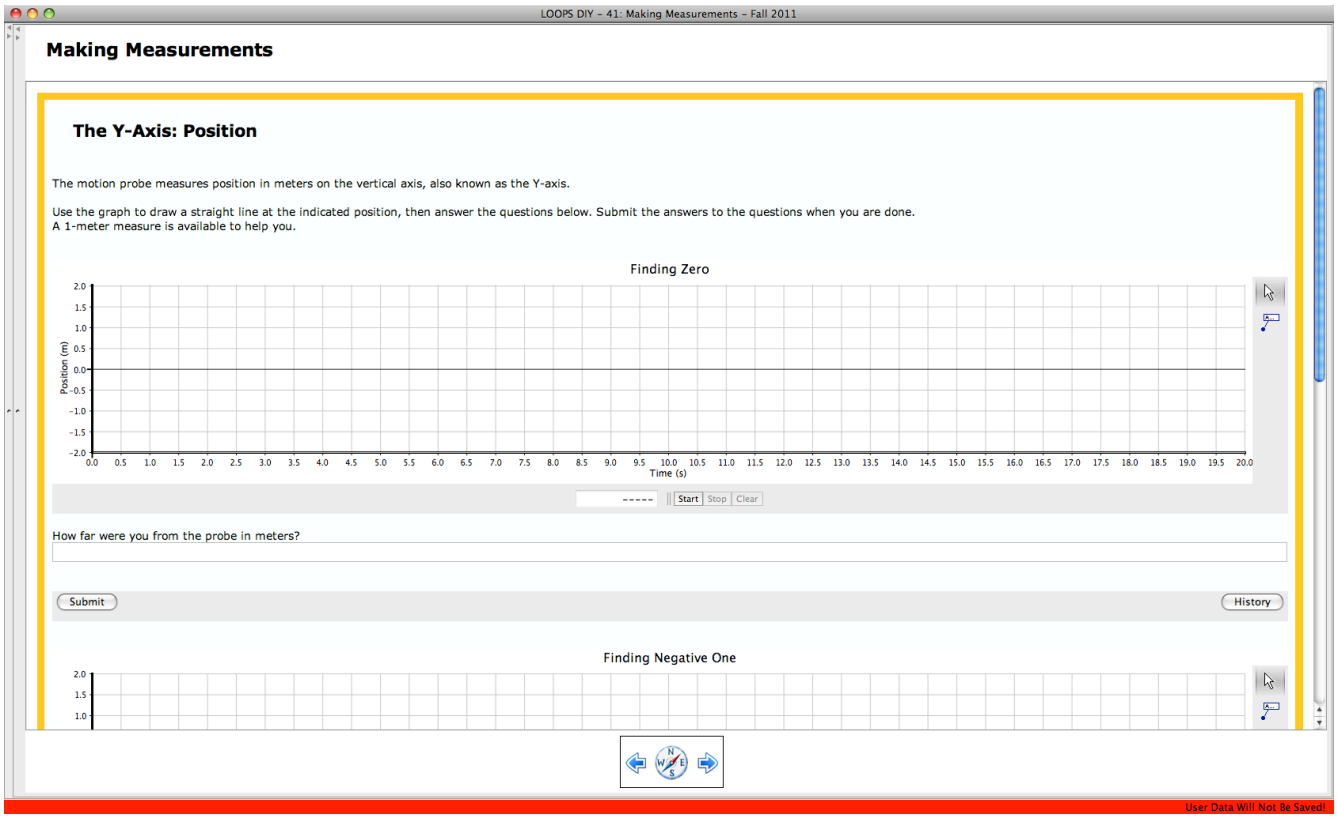


Things to Notice:

1) How did you find the duration between two events?
2) How can you be more accurate in your measurements?

The Y-Axis: Position

In this step, students use motion probe to find the location of specific positions.



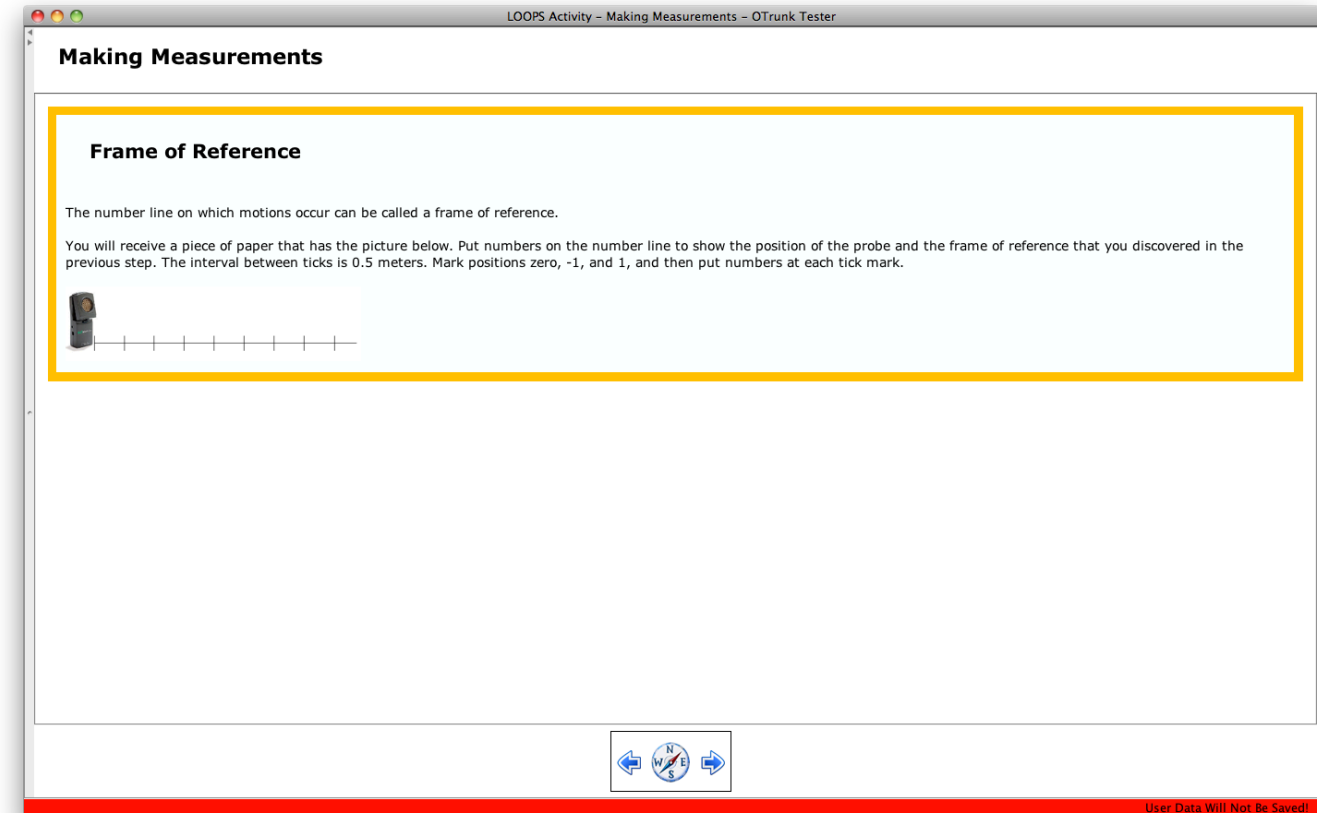
Students will find the positions of zero, negative one, and positive one on separate motion graphs.

Things to Notice:

1) How can you find the location of specific positions? How did you figure it out?
2) Did everyone find the same distance for each position?

Frame of Reference

In this step, students draw a frame of reference on a piece of paper. The LOOPS project will provide paper for the students.



Things to Notice:

1) How far from the probe are you when at position zero?
2) What is the motion probe's position?

Calculating Distances from Positions

In this step, students calculate distances between two positions.

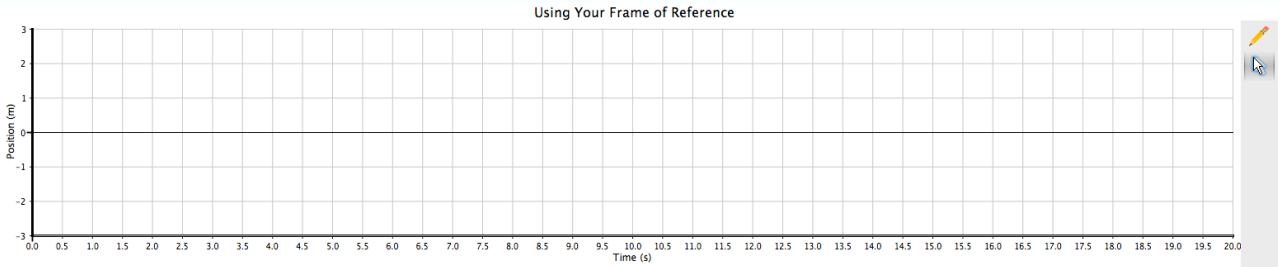
Making Measurements

Calculating Distances from Positions

Draw on the graph below the movement described:

- stay still at 2 m for 4 s
- move to 1 m and stay still for 4 s
- move to -1 m and stay still for 4 s
- move to -2 m and stay still for 4 s

and Submit your graph.



What is the distance between positions 2 and 1?

- 1
- 2
- 3
- 4

Submit History

What is the distance between positions 1 and -1?

- -2
- 0
- 1
- 2

Submit History

What is the distance between positions -1 and -2?

- -3
- -1
- 1
- 2

Submit History

Things to Notice:

1) Use the multiple-choice items as diagnostic devices to measure students' understanding of calculations.
2) How can the graph be used to measure distance between two locations?
3) Use the multiple-choice item as a diagnostic to see how students have fared with calculating distances from positions.

Distractor Analysis for distance between 2 and 1:

Choice 1: 1

This is the correct answer. The distance between 2 and 1 is 1.

Choice 2: 2

Students who choose this answer may be multiplying or dividing the numbers to find distance.

Choice 3: 3

Students who choose this answer may be adding the numbers to find the distance.

Choice 4: 4

Students who choose this answer may be reading the time intervals between the numbers (as they have drawn the graph).

Distractor Analysis for distance between 1 and -1:

Choice 1: -2

Students who choose this answer may think that since one position is negative the distance must also be negative.

Choice 2: 0

Students who choose this answer may be subtracting 1 from 1,since one of the numbers is negative.

Choice 3: 1

Students who choose this answer may think that distance can be calculated only from positive numbers.

Choice 4: 2

This answer is correct. The distance between 1 and -1 is 2.

Distractor Analysis for distance between -1 and -2:

Choice 1: -3

Students who choose this answer may be adding the numbers to find the distance since both are negative.

Choice 2: -1

Students who choose this answer may think that since both positions are negative, the distance must also be negative.

Choice 3: 1

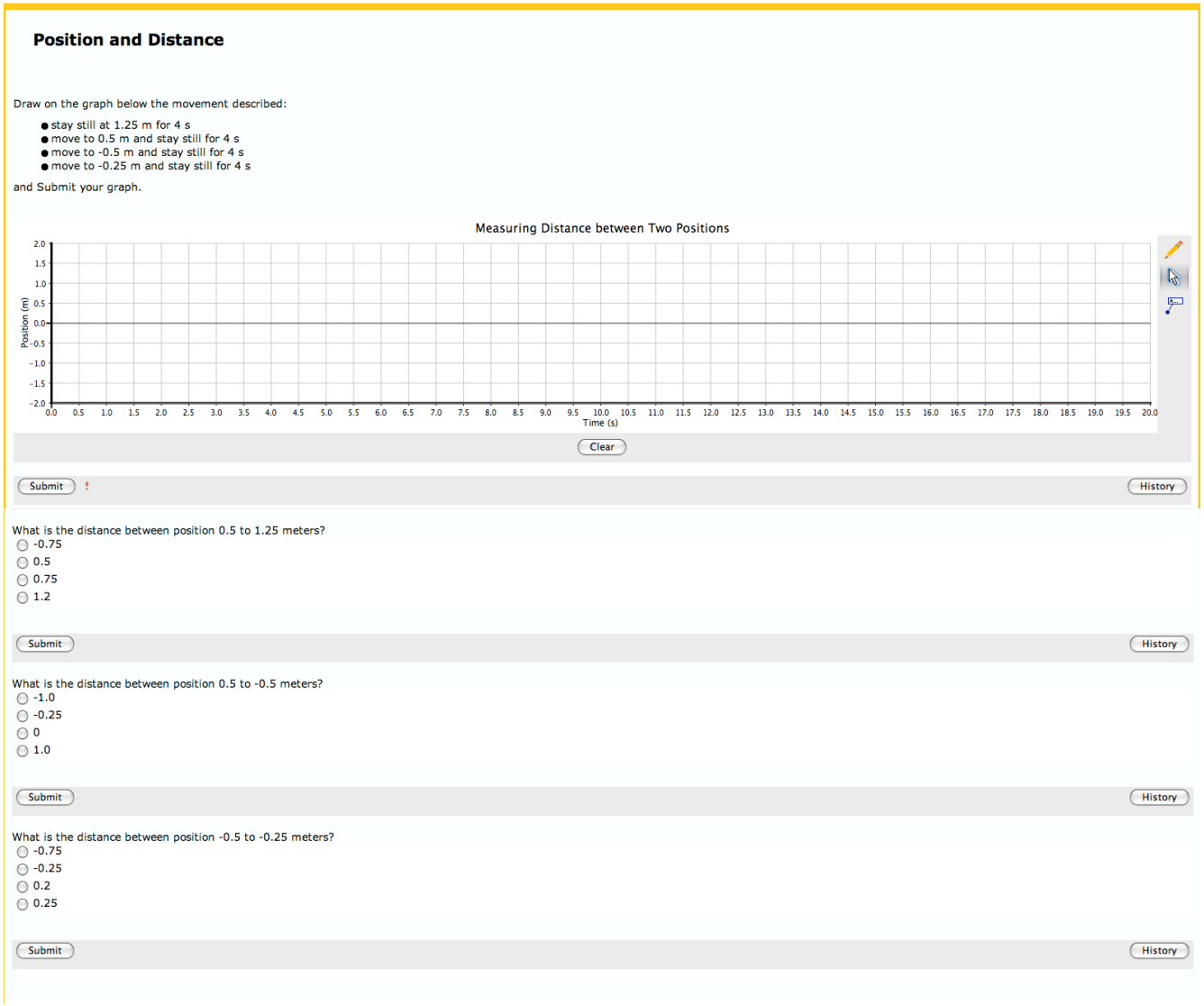
This is the correct answer. The distance between -1 and -2 is 1.

Choice 4: 2

Students who choose this answer may be multiplying the numbers to find the distance between them.

Position and Distance

In this step, students calculate distances between two positions, using fractional numbers.



Things to Notice:

1) Use the multiple-choice items as diagnostic devices to measure students' understanding of calculations.
2) How can the graph be used to measure distance between two locations?
3) Use the multiple-choice item as a diagnostic to see how students have fared with calculating distances from positions.

Distractor Analysis for distance between 0.5 and 1.25:

Choice 1: -0.75

Students who choose this answer may have subtracted 1.25 from 0.5.

Choice 2: 0.5

Students who choose this answer may have forgotten about the .25 on the 1.25.

Choice 3: 0.75

This is the correct answer. The distance between 0.5 and 1.25 is 0.75.

Choice 4: 1.2

Students who choose this answer may think that the 5s cancel each other so they can be ignored.

Distractor Analysis for distance between 0.5 and -0.5:

Choice 1: -1.0

Students who choose this answer may think that the distance should be negative since one of the positions is negative.

Choice 2: -0.25

Students who choose this answer may be multiplying the numbers to find distance.

Choice 3: 0

Students who choose this answer may be adding the numbers to find the distance.

Choice 4: 1.0

This is the correct answer. The distance between 0.5 and -0.5 is 1.

Distractor Analysis for distance between -0.5 and -0.25:

Choice 1: -0.75

Students who choose this answer may be adding the numbers to find the distance.

Choice 2: -0.25

Students who choose this answer may think that the distance should be negative since both positions are negative.

Choice 3: 0.2

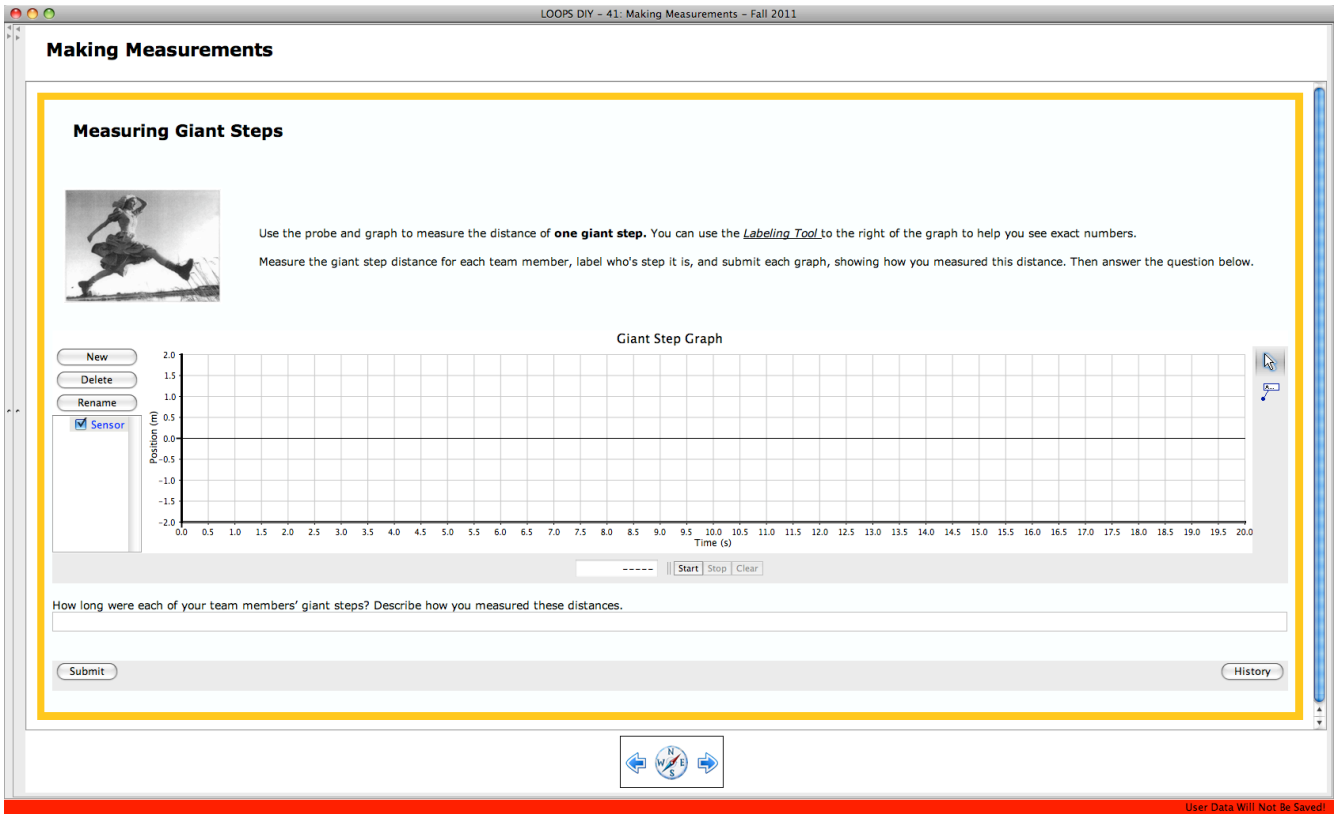
Students who choose this answer may think that the 5s cancel each other so they can be ignored.

Choice 4: 0.25

This is the correct answer. The distance between -0.5 and -0.25 is 0.25.

Measuring Giant Steps

In this step, students calculate the length of one giant step.

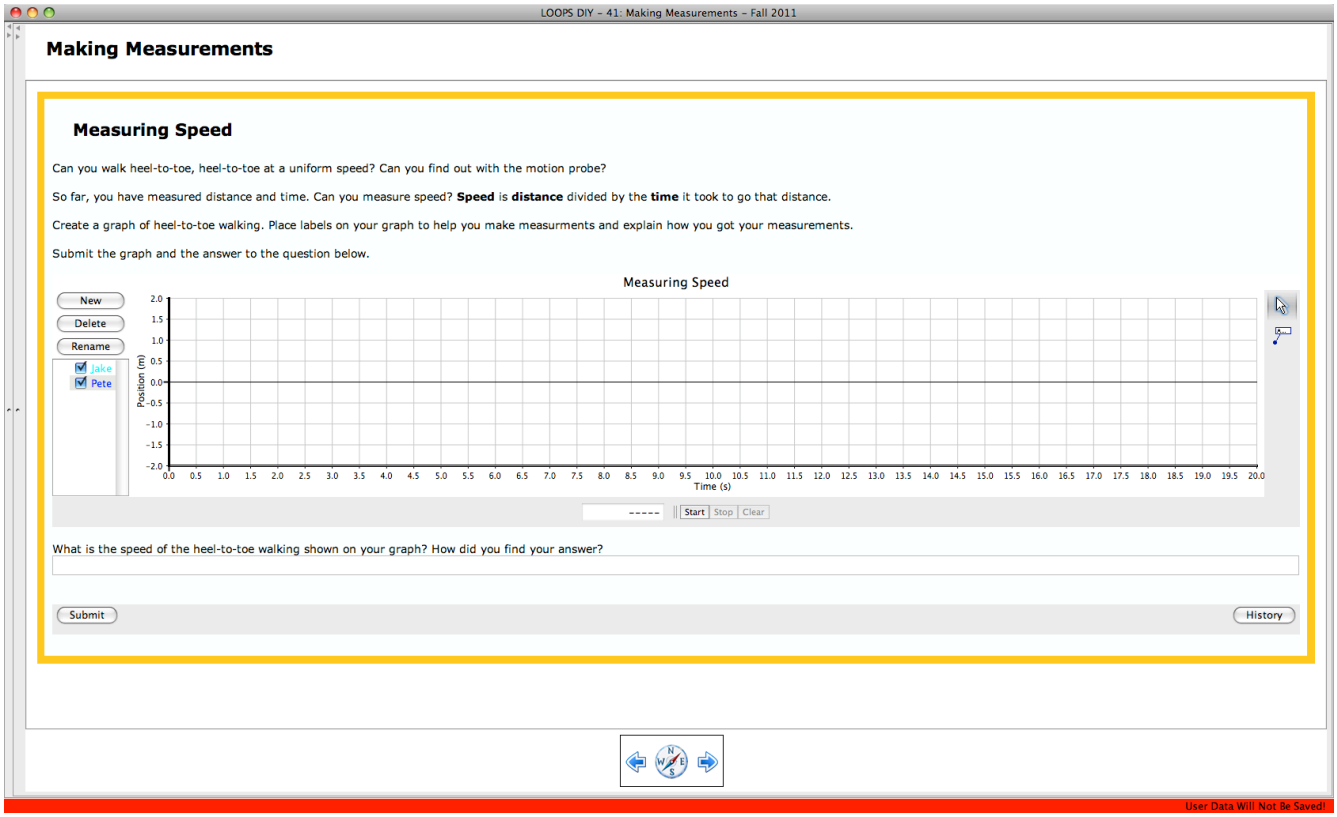


Things to Notice:

1) Do the calculations of step length match what's shown on the graph?
2) How did different students make their giant steps?
3) Who has the longest giant step?

Measuring Speed

In this step, students calculate the speed of their walking.



Things to Notice:

1) Which portion of the graph did you measure? Was that a valid interval to measure speed?
2) Did you use the same points to measure time and distance?
3) Is this a constant speed (qualitative look at slope)?
4) Who was faster? How can you tell?
5) In which direction did you walk? Does it make a difference?

Telling Stories

Learning Goals:
1. Be able to create and interpret a number line/graph based on a frame of reference. Positions may be on a number line that may include negative numbers.

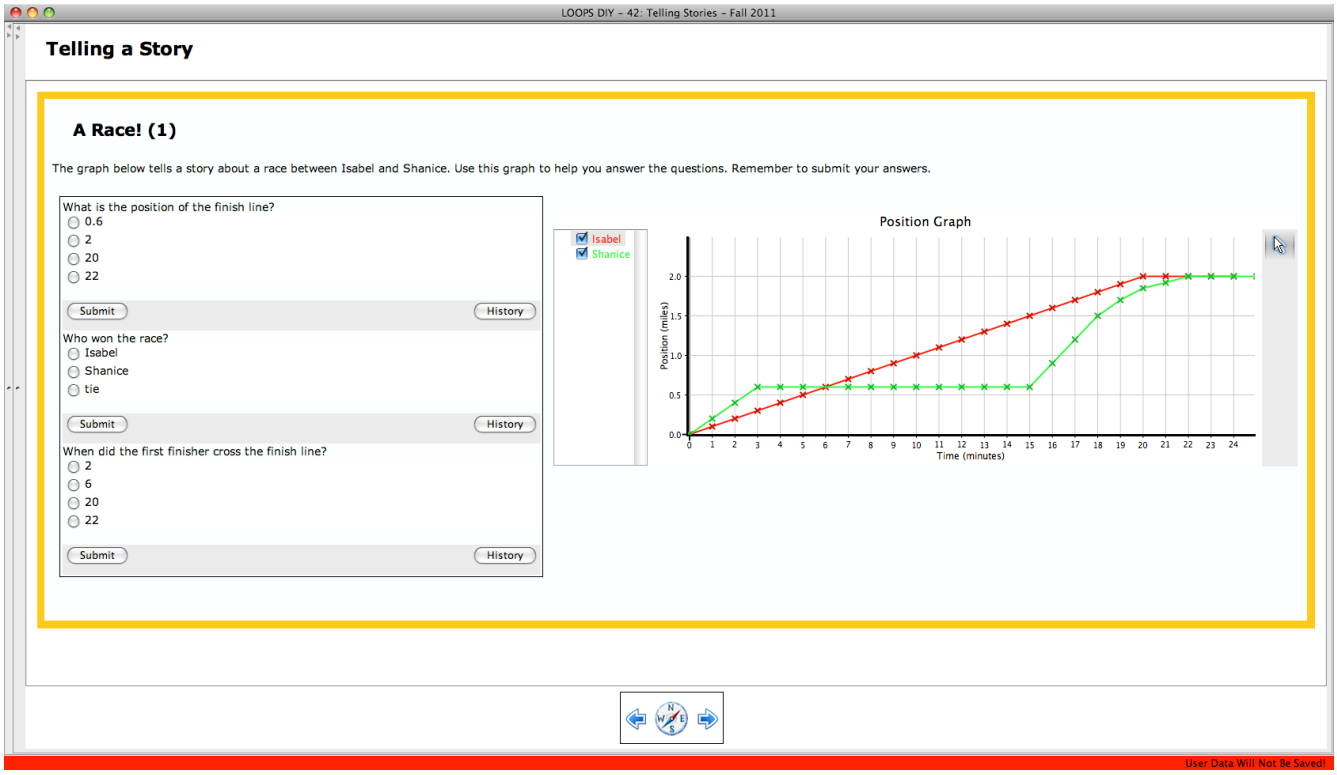
2. Be able to interpret graphs of position vs. time and describe quantitatively the motion represented
   a) measurements/calculations of distance between two positions
   b) measurements/calculations of duration between two events

3. Be able to create a graph of position vs. time that matches a motion story.

4. Be able to calculate velocity from a position vs. time graph.

A Race! (1)

In this step, students interpret a graph with two lines.



Things to Notice:

1) Multiple-choice items provide diagnostic opportunities.
2) Use the multiple-choice item as a diagnostic to see how students have understood the graph.

Distractor Analysis for position of the finish line:

Choice 1: 0.6

Students who choose this answer may think that the race ends when Shanice stops moving.

Choice 2: 2

This is the correct answer.

Choice 3: 20

Students who choose this answer think that the time that it takes Isabel to run the race is the position of the finish line. Students are looking for position on the wrong (x) axis.

Choice 4: 22

Students who choose this answer think that the time that it takes Shanice to run the race is the position of the finish line. Students are looking for position on the wrong (x) axis.

Distractor Analysis for who won the race:

Choice 1: Isabel

This is the correct answer.

Choice 2: Shanice

Students who choose this answer may think that the race ends at the 0.6 mile position when Shanice stops moving and that the rest of the motion shows the girls' motions after the race has ended.

Distractor Analysis for when the first finisher crossed the finish line:

Choice 1: 2

Students who choose this answer are looking for time on the wrong (y) axis.

Choice 2: 6

Students who choose this answer may think that crossing the finish line is shown when the lines showing Shanice's and Isabel's movements cross at the 6 minute mark.

Choice 3: 20

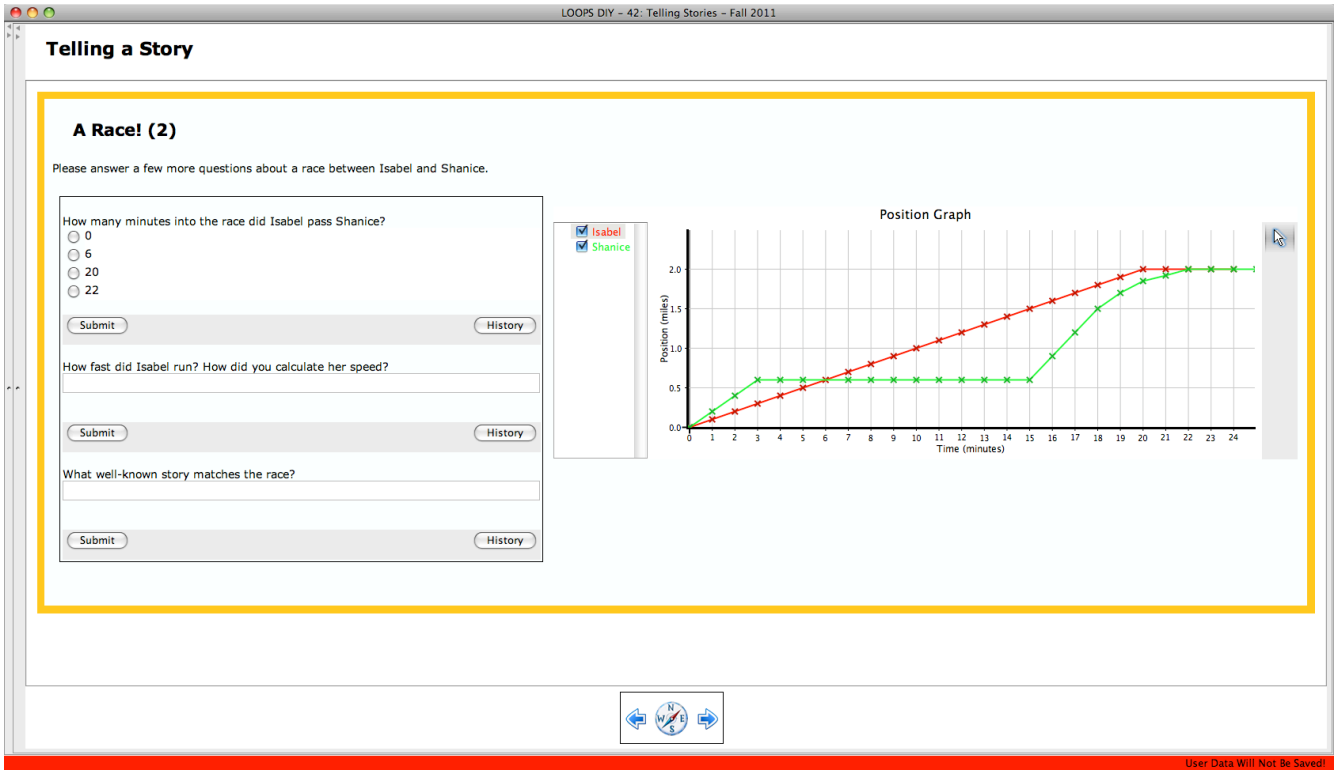
This is the correct answer.

Choice 4: 22

Students who choose this answer may think that Shanice was the first finisher.

A Race! (2)

In this step, students interpret a graph with two lines.



Things to Notice:

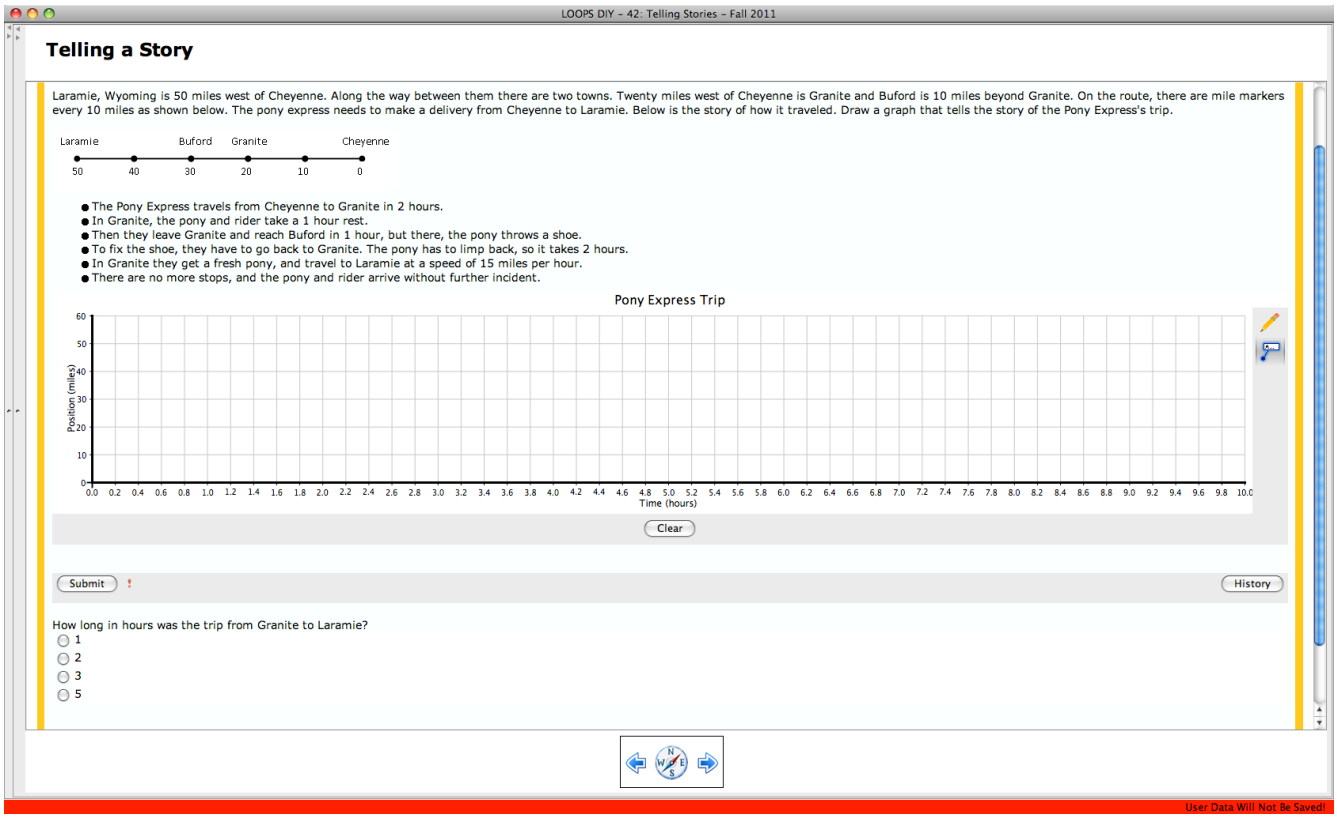
1) Use the multiple-choice item as a diagnostic to see how students have understood the graph.

   Distractor Analysis for how many minutes into the race Isabel passed Shanice:
   Choice 1: 0
   Students who choose this answer may think that Isabel passed Shanice at the start line.
   Choice 2: 6
   This is the correct answer.
   Choice 3: 20
   Students who choose this answer think that Isabel passed Shanice when she crossed the finish line.
   Choice 4: 22
   Students who choose this answer think that Isabel passed Shanice when Shanice crossed the finish line.

2) Remind students that speed has units (distance and time). Have them think about the units to remember how to arrange the numbers in the formula.

The Pony Express

In this step, students draw a graph from a story.



Things to Notice:

1) How did you decide how to draw the last segment of the graph?
2) How do you calculate time from a speed and a distance?
3) Use the multiple-choice item as a diagnostic to see how students have fared with calculating time.

Distractor Analysis for time of the trip from Granite to Laramie:

Choice 1: 1 hour

Students who choose this answer may think that the time spent resting in Granite is the time for the trip from Granite to Laramie.

Choice 2: 2 hours

This is the correct answer. At a speed of 15 miles per hour, the 30 mile trip between Granite and Laramie would take 2 hours.

Choice 3: 3 hours

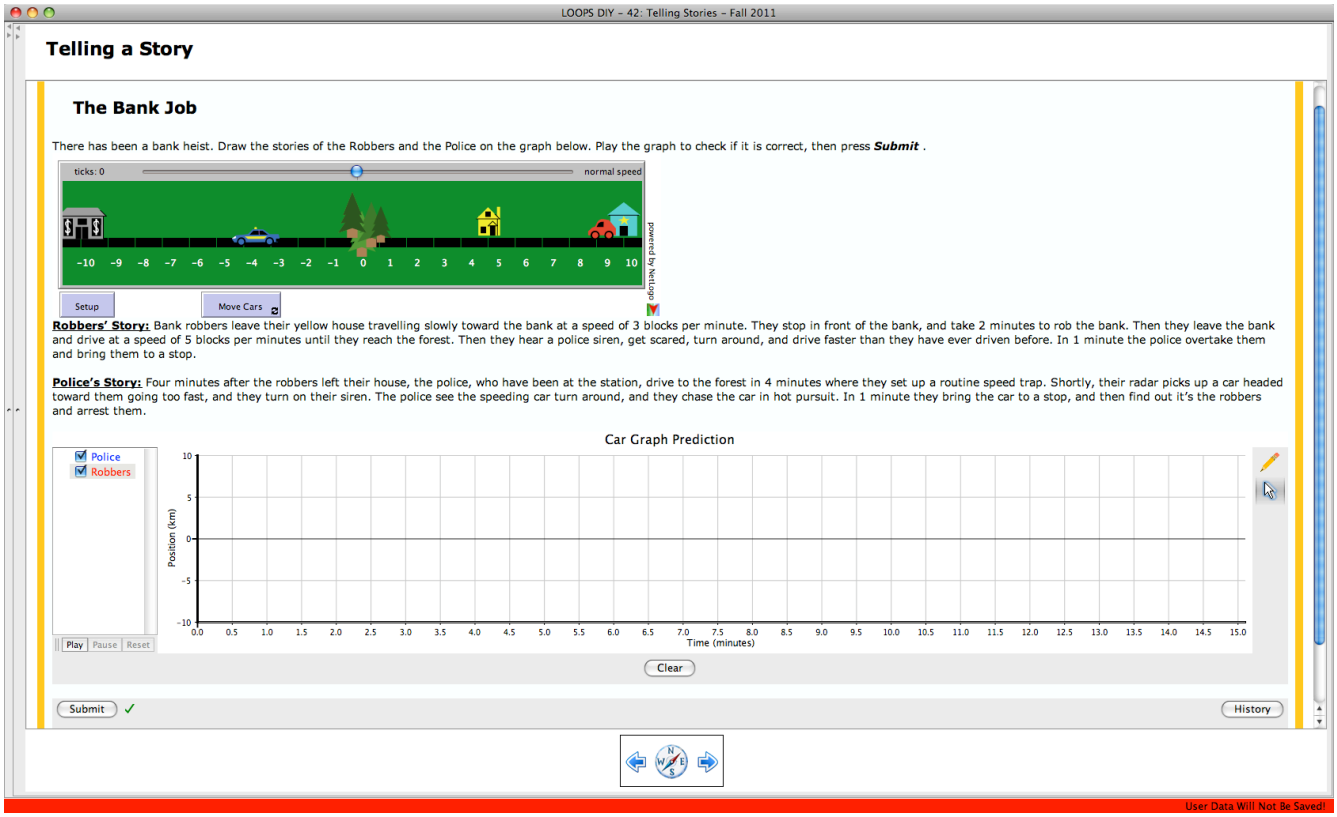
Students who choose this answer may be adding the time spent to get to Granite (from Cheyenne) with the rest at Granite, or they may be adding the time it takes to get to Granite via Buford (1 hour plus 2 hours of limping back).

Choice 4: 5 hours

Students who choose this answer may be adding all of the times to get to Granite and Laramie (1 hour to get to Buford from Granite, 2 hours to limp back to Granite, and 2 hours to get from Granite to Laramie).

The Bank Job

In this step, students draw two interlinked stories on the same graph. They can check their graph by playing the model.

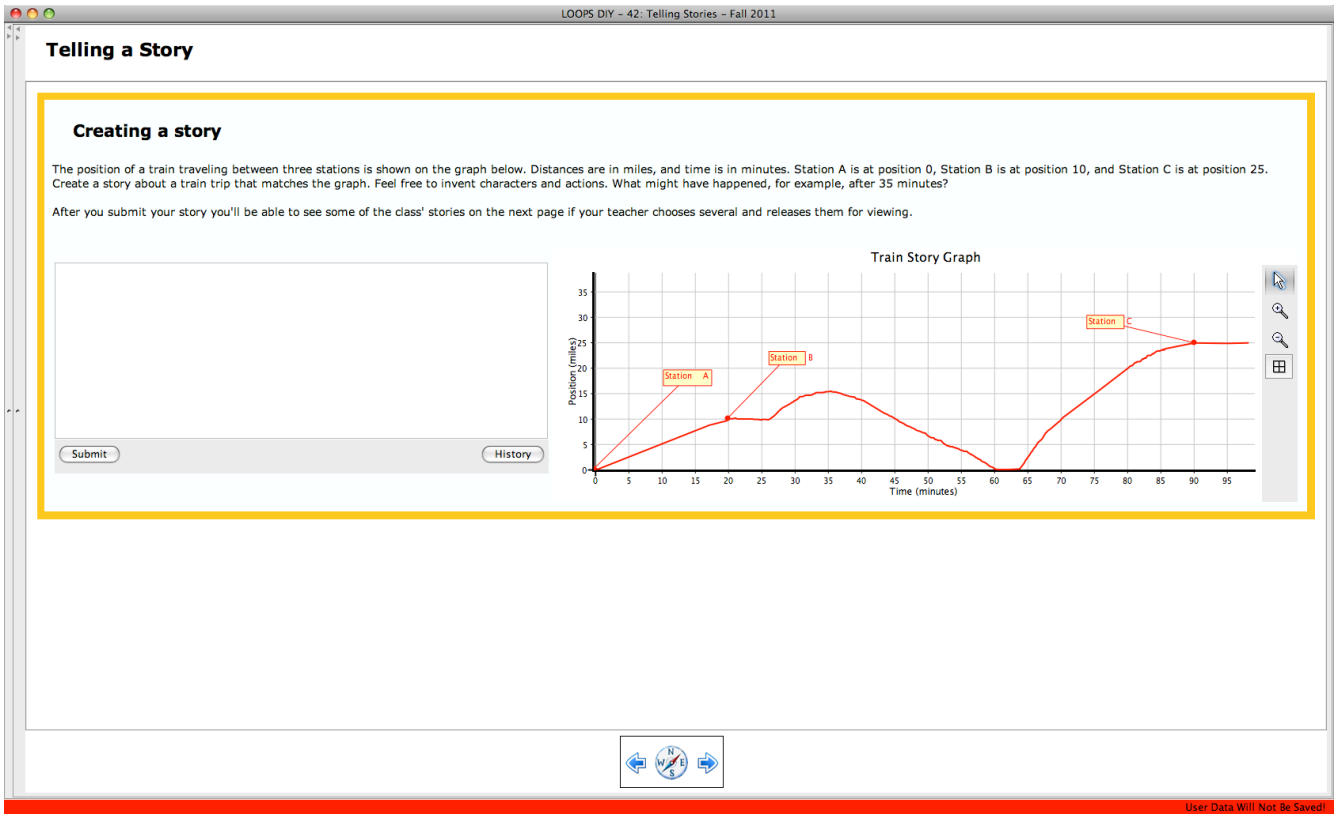


Things to Notice:

1) Does the graph match the stories?
2) How did you draw the robbers' story?

Creating a Story

In this step, students create a story to match a graph.



Things to Notice:

1) Does the story match the graph?
2) Is there enough detail in the story to draw the graph?