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Using technology to understand rate of change

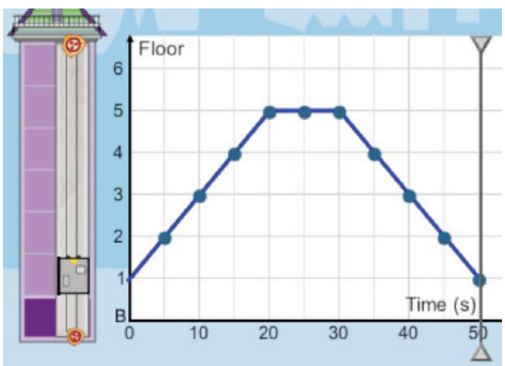
The following series of learning activities are from an afterschool math club called Go Go Gizmos that focuses on modeling mathematics with the use of technologies. This account describes how a classroom teacher and a math educator taught and assessed students' understanding of the rate of change using a variety of technologies. In particular, we chose data collection probeware called Go!Motion, which is a stand-alone motion-data–collection device from Vernier that sends data to the computer for analysis and simulation applets from http://explorelearning.com. The Go!Motion device can be connected to a computer and displays an interactive real-time spreadsheet with graphing capabilities. The objectives in the unit were for students to investigate physical representations of slope as a rate of change in mathematics and as velocity in science and the *y*-intercept as the initial condition, or starting position. In these investigations, students and teachers become partners in developing mathematical ideas and solving math problems (NCTM 2000).

For the first learning activity, students explored an interactive tool called the *Elevator Operator* from explorelearning.com. The objective of the technology task was to find and interpret the coordinates of a point on a graph and connect the motion of an elevator to its representation on a line graph. Moreover, some important mathematics related to the task was to recognize that a line with a positive slope represents the elevator going up; a line with a negative slope represents the elevator going down; a horizontal line represents the elevator at rest; and a steeper line represents faster motion.

Before the computer-simulated task, we gave a preassessment and found that sixteen of seventeen students incorrectly answered the question in **figure 1**. They chose choice A instead of choice C. This assessment made clear that many students had a misconception that the horizontal line represents a sideways movement. On the basis of assessment results, we decided that to understand the line graph, students needed a real-time data-collection

FIGURE 1

This item from an assessment revealed students' misconception that the horizontal line represents a sideways movement.



Interpret the story of motion depicted by this line graph. What does the graph show?

A. The elevator went up for 20 seconds, went sideways for 10 seconds, and then went down for 20 seconds.
B. The elevator started on the 0th floor, went up to the 20th floor, went up to the 30th floor, and then went up to the 50th floor.
C. The elevator went up for 20 seconds, did not move for 10 seconds, and then went down for 20 seconds.
D. The elevator sped up for 20 seconds, stayed at the same speed for 10 seconds, and then slowed down for 20 seconds.

FIGURE 2

Using Vernier's Go!Motion to collect real-time data, students walked forward and back in front of the motion probe.

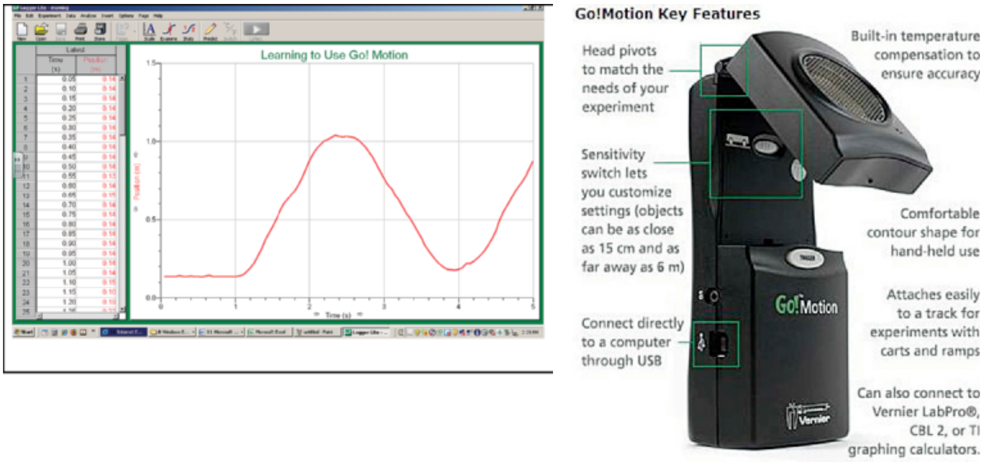
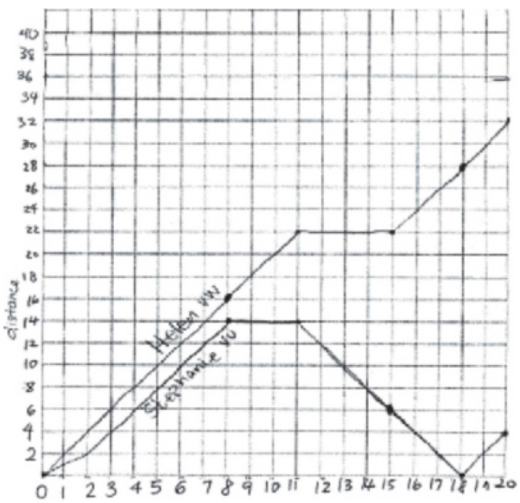


FIGURE 3

Students paired up, drew line graphs, and wrote stories to match their graphs. Some began by acting out the motion; others drew the graph first and then told a story to match.



Stephanie and Helen were forgetful girls who loved to run track. One day, Stephanie and Helen ran a sprint race. Stephanie ran 14 meters; then she realized that she wasn't wearing her shoes. She stopped for 3 seconds to think about where she took them off and ran back to the starting line. When Stephanie glanced back, she saw Helen getting closer to the finish line, and so she said, "Forget those shoes!" Then she started running toward the finish line again. In the other lane, Helen was a fast runner and had run 22 meters when she realized she had forgotten to take her lucky watch from her trainer. She paused for 4 seconds, but then she remembered that she wore her watch on her other arm. So she continued to run her course and won the race.

experience with a motion probe. Thus, in the next lesson, we connected the computers to Vernier's Go!Motion and had students track their movement by walking forward and back in front of the motion probe (see **fig. 2**). Only after they had used the real tools were they convinced that a horizontal line indicates rest, that a line with positive slope represents the walker farther from the start position, and that a line with negative slope represents the walker coming back toward the start position.

The use of the technology not only amplified student learning but also served as a way to dispel their misconception. On the basis of this experience, we decided to follow up with a third related lesson in a creative math writing activity called Graphic Stories. The excerpt in **figure 3** is from two students who worked on a graphic

FIGURE 4

This simulation links a graph with animation (http://explorelearning.com).

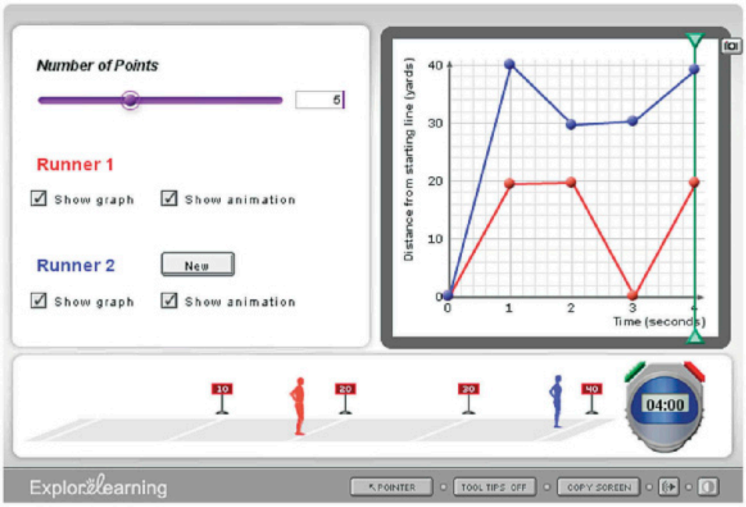


FIGURE 5

At the end of the related lessons, the class created a generalization poster to summarize the characteristics of slopes.

The slope of a line graph may be positive / or negative \ or zero — .

The steepness of the line called the *slope* tells a story. For example, in our Elevator Operator activity, the elevator started on the first floor and went up to the fifth floor and stayed at the same level for 15 seconds before going down to the basement. Then it traveled back up to the fifth floor and stayed there until time was up.

story and presented their work in the collective workspace.

In addition to creating a story and drawing a graph, students worked with the two running men in Distance-Time Graphs, an applet from explorelearning.com, to make their learning concrete (see **fig. 4**). After students wrote a story, they had to role-play the script of their graphic story using Go!Motion to see if they could re-create their hand-drawn line graph with the GO!Motion sensor and graphing software.

These related tasks provided an opportunity for students to work in multiple representations translating among graphical, tabular, and verbal description in a real-life context. At the end of the related lessons, the class created a generalization poster (see **fig. 5**) to summarize the characteristics of slopes. Use of these technologies allowed students to collect, organize, display, analyze, and interpret real-world data in real time. We were deliberate in developing and posing problems that are related yet increasingly more complex. Our selection of problems allowed students to naturally make connections to previous problems they had solved in class and to build on the knowledge they had acquired. Their interaction with probeware, with its display of tabular and graphical representations, served as way to amplify the mathematics and dispel students' misconceptions about slope and rate of change.

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