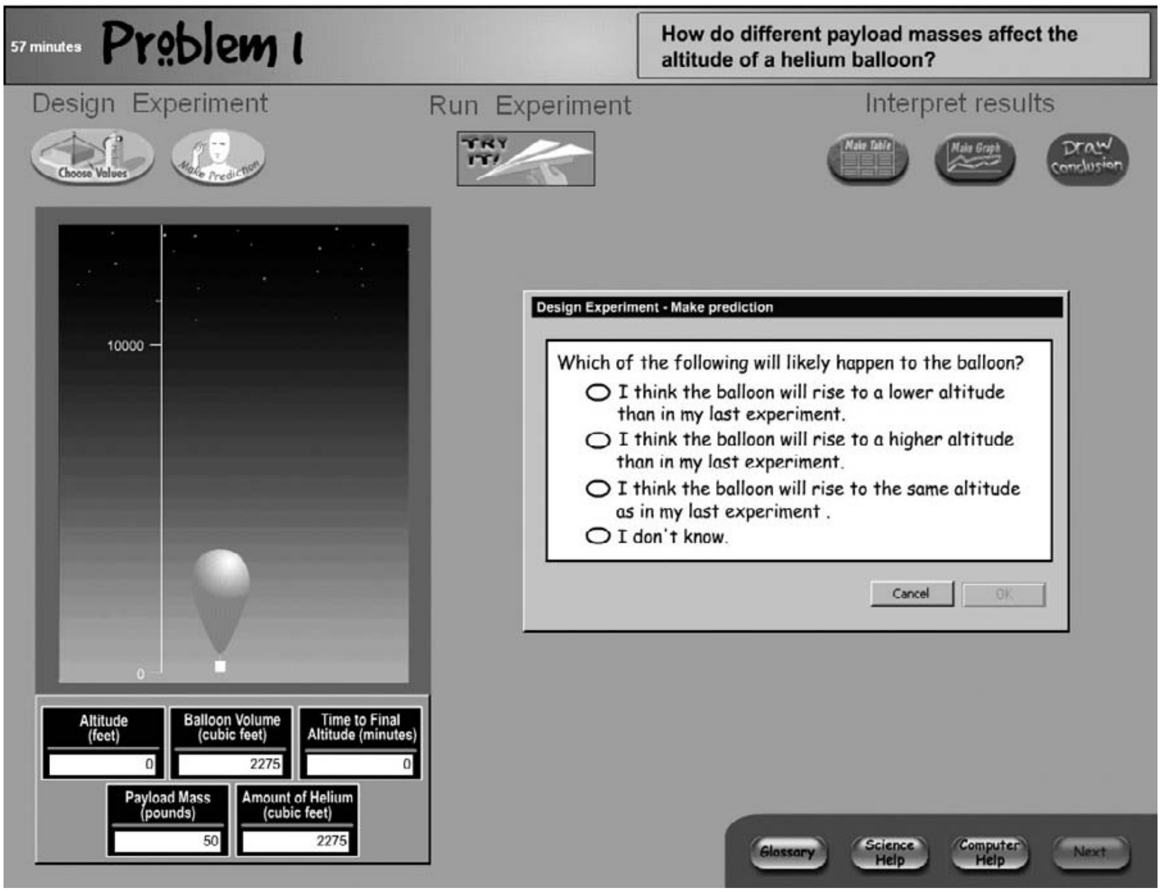
After choosing a value for mass, students could choose to make a prediction. Figure 1-13 displays the four possible options. By comparing the current experiment to the previous one, the options were intended to encourage students to think in terms of patterns of results: in this case, the impact on balloon altitude of varying the payload masses. (Although more might have been learned by requiring students to key-enter predictions and interim hypotheses about the relationship between mass and balloon altitude, limited assessment time discouraged this more in-depth approach.)

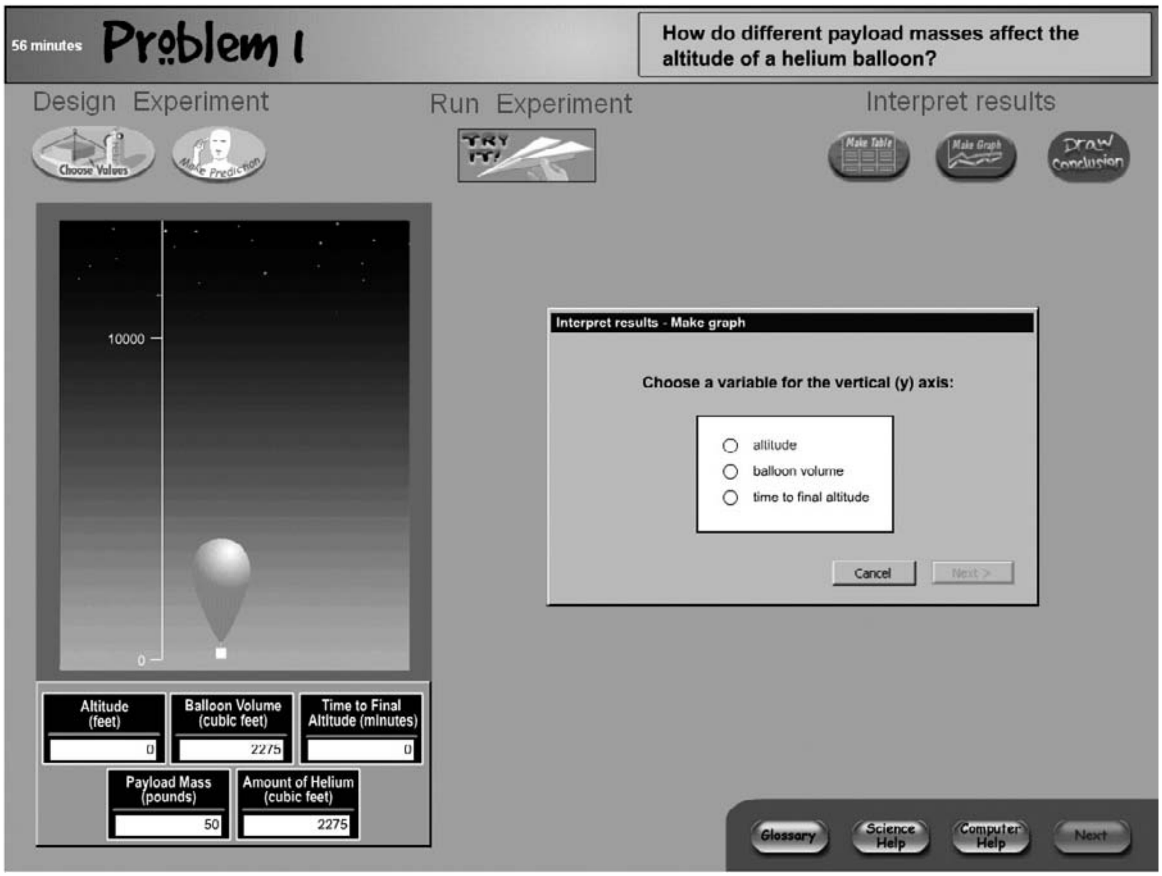
**Figure 1-13.** Computer screen with the prediction options in TRE Simulation scenario problem 1, grade 8: 2003




NOTE: TRE = Technology-Rich Environments.
SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2003 Problem Solving in Technology-Rich Environments Study.

To help interpret data, students could make a graph, a table, or both. Clicking on the Make Graph button opened a dialog box that asked students to select a variable for the vertical axis (see figure 1-14) and then, in a subsequent box, for the horizontal axis. Note that students had leeway to get into trouble by choosing less relevant or incorrect variables for either graph axis; this design allowed an opportunity to determine whether students created interpretive tools related to the problem they were supposed to be solving.

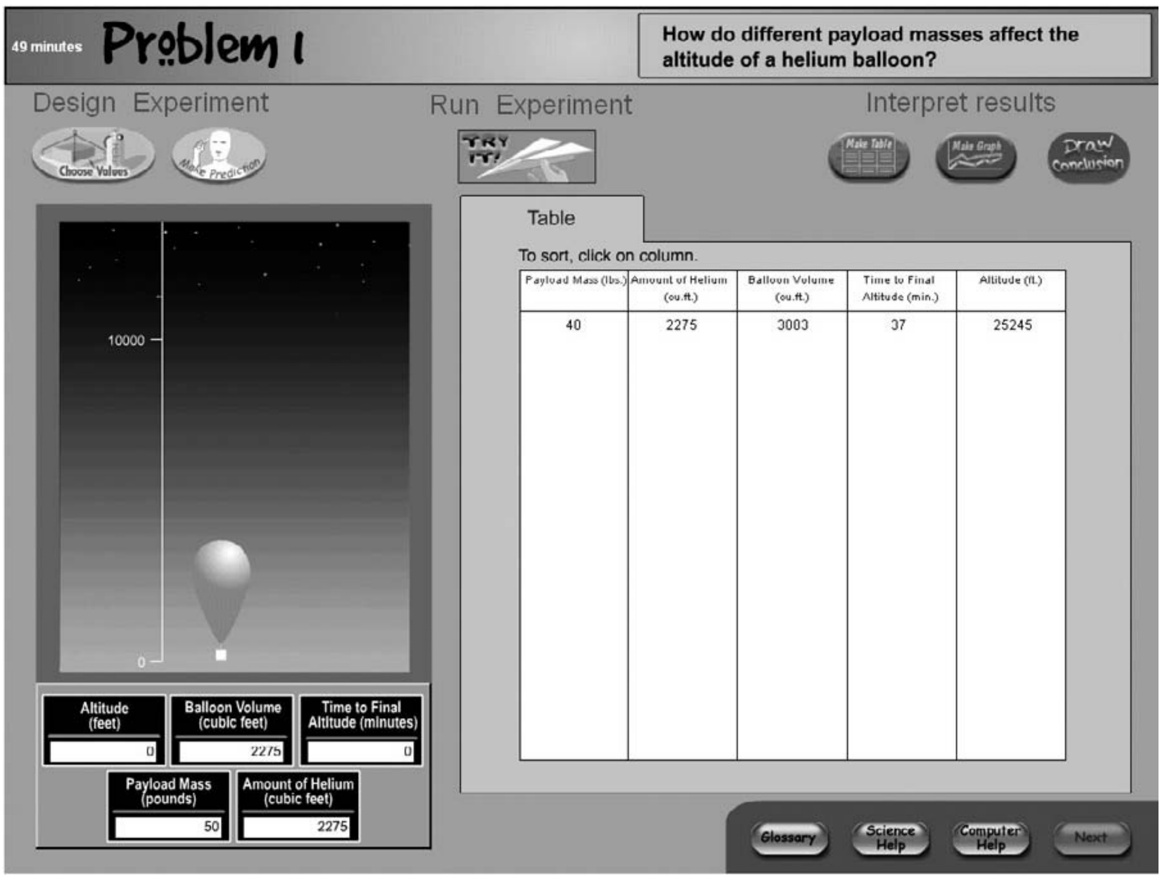
**Figure 1-14.** Computer screen with dialog box for creating a graph in TRE Simulation scenario problem 1, grade 8: 2003




NOTE: TRE = Technology-Rich Environments.
SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2003 Problem Solving in Technology-Rich Environments Study.

Similarly, students could construct a table by choosing from the variables tracked in the instrument panel. The resulting displays may, therefore, have contained relevant information, some relevant and some irrelevant information, or only irrelevant information. If, for example, a student chose to include all five variables, the table would appear as in figure 1-15. A more helpful table for problem 1 would be limited to the dependent and independent variables necessary to solve the problem—altitude and mass. For each subsequent experiment that students chose to conduct, a line of data was added to the table automatically. Students could sort the table on any variable by clicking on the appropriate column heading.

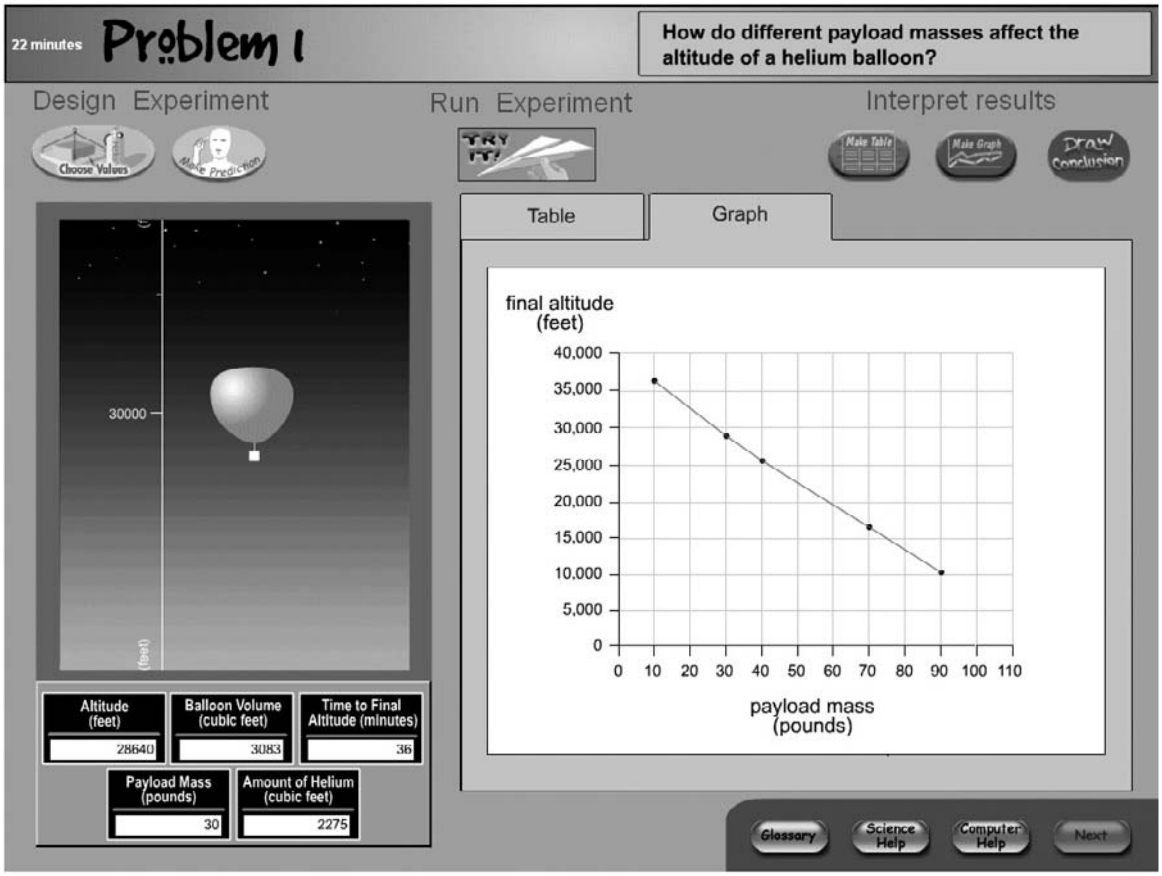
**Figure 1-15.** Computer screen with a table of results for one experiment conducted in TRE Simulation scenario problem 1, grade 8: 2003




NOTE: TRE = Technology-Rich Environments.
SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2003 Problem Solving in Technology-Rich Environments Study.

Note that the relationship to be discovered in problem 1 was a virtually linear, negative one: as mass increases, the altitude the balloon can achieve decreases. Figure 1-16 shows the display that would result from creating a graph with the relevant variables and experiments with a sufficient range of masses.[6]

**Figure 1-16.** Computer screen with a graph of the relationship between altitude and mass in TRE Simulation scenario motivating problem 1, grade 8: 2003

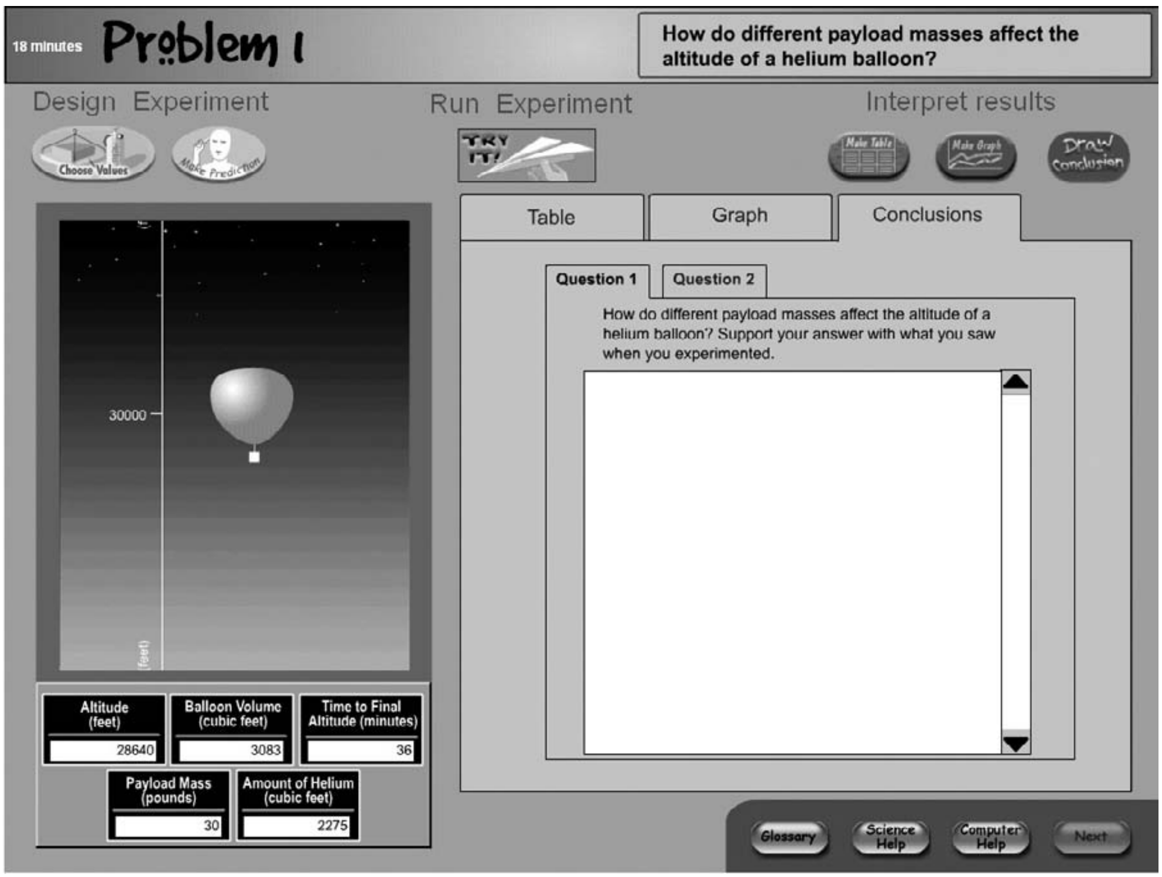



NOTE: TRE = Technology-Rich Environments.
SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2003 Problem Solving in Technology-Rich Environments Study.

[6] Students in the TRE study could have used non-technological alternatives like paper-and-pencil in place of creating an electronic table or graph. The extent to which such alternatives were used could not be determined.

When ready, students could click on the Draw Conclusions button to bring up a text-entry box, as shown in figure 1-17. This box called for students to construct a response to the problem about the relationship between payload mass and altitude and to support the answer with experimental observations. Before completing the response, students could choose to revisit an existing table or graph, construct new tables or graphs, or conduct more experiments.

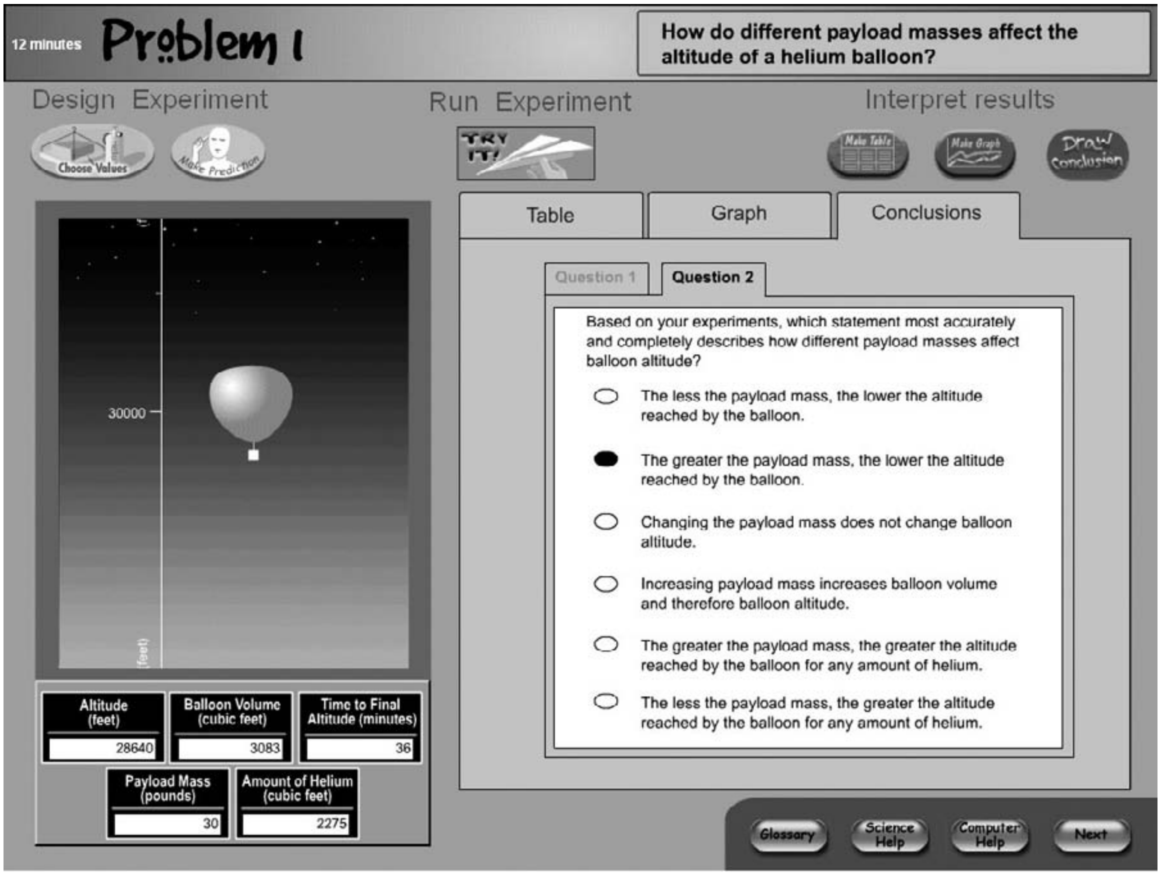
**Figure 1-17.** Computer screen with the box for answering the TRE Simulation scenario motivating problem 1, grade 8: 2003




NOTE: TRE = Technology-Rich Environments.
SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2003 Problem Solving in Technology-Rich Environments Study.

Having completed their written responses, students were required to respond to a multiple-choice question (see figure 1-18), which provided an alternative measure for those individuals unable to express adequately their understanding of the mass-altitude relationship in writing.

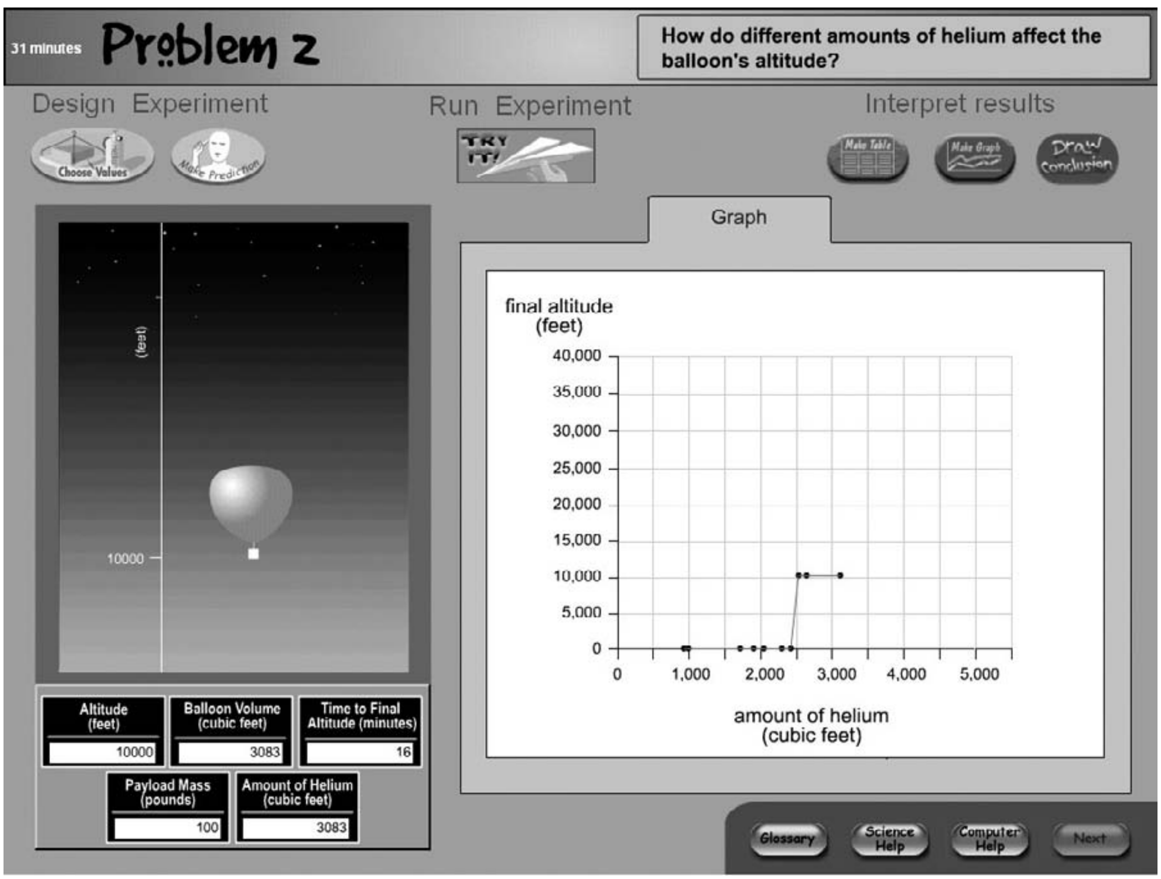
**Figure 1-18.** Computer screen with the multiple-choice question concluding TRE Simulation scenario problem 1, grade 8: 2003




NOTE: TRE = Technology-Rich Environments.
SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2003 Problem Solving in Technology-Rich Environments Study.

The second Simulation problem asked students to determine the relationship between the amount of helium put in the balloon and the altitude that the balloon could reach. This time, the payload mass the balloon carried was fixed. Problem 2 was conceptually more difficult because the relationship students had to discover was not linear. Rather, the relationship took the form of a step function. That is, until a critical amount of helium was put in the balloon, the balloon did not leave the ground; once that critical amount of helium was achieved, the balloon would rise to a maximum altitude, then go no higher regardless of how much more helium was put into it. To recognize the relationship, students had to choose a sufficient number and range of values and not draw conclusions prematurely; a premature conclusion would lead them to assume falsely either that the amount of helium did not matter, or that the balloon would continue to rise higher as it was filled with more helium. Figure 1-19 displays what the graph

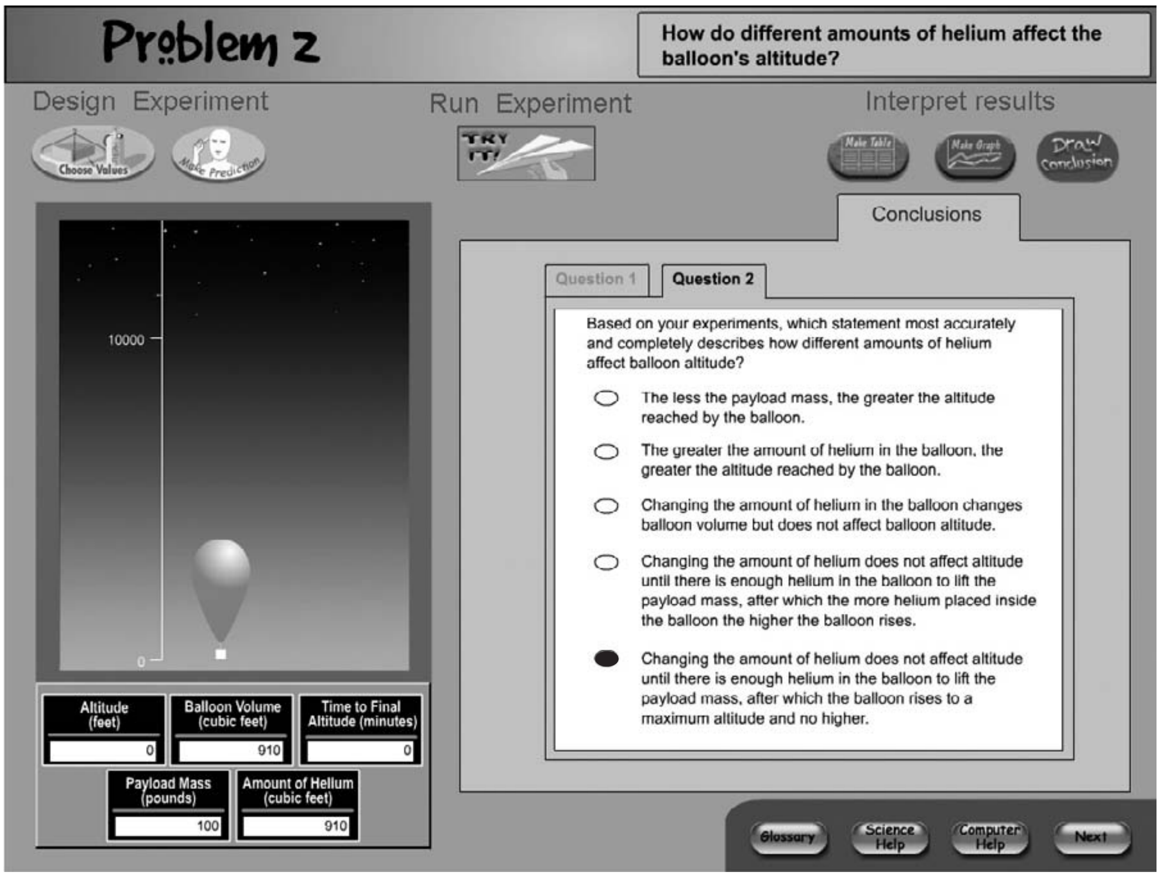
**Figure 1-19.** Computer screen with a graph of the relationship between altitude and amount of helium in TRE Simulation scenario problem 2, grade 8: 2003




NOTE: TRE = Technology-Rich Environments.
SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2003 Problem Solving in Technology-Rich Environments Study.

looked like with the relevant variables and sufficient experiments to reveal the step function. Figure 1-20 shows the multiple-choice question that students were asked to answer after they entered the constructed response to problem 2.

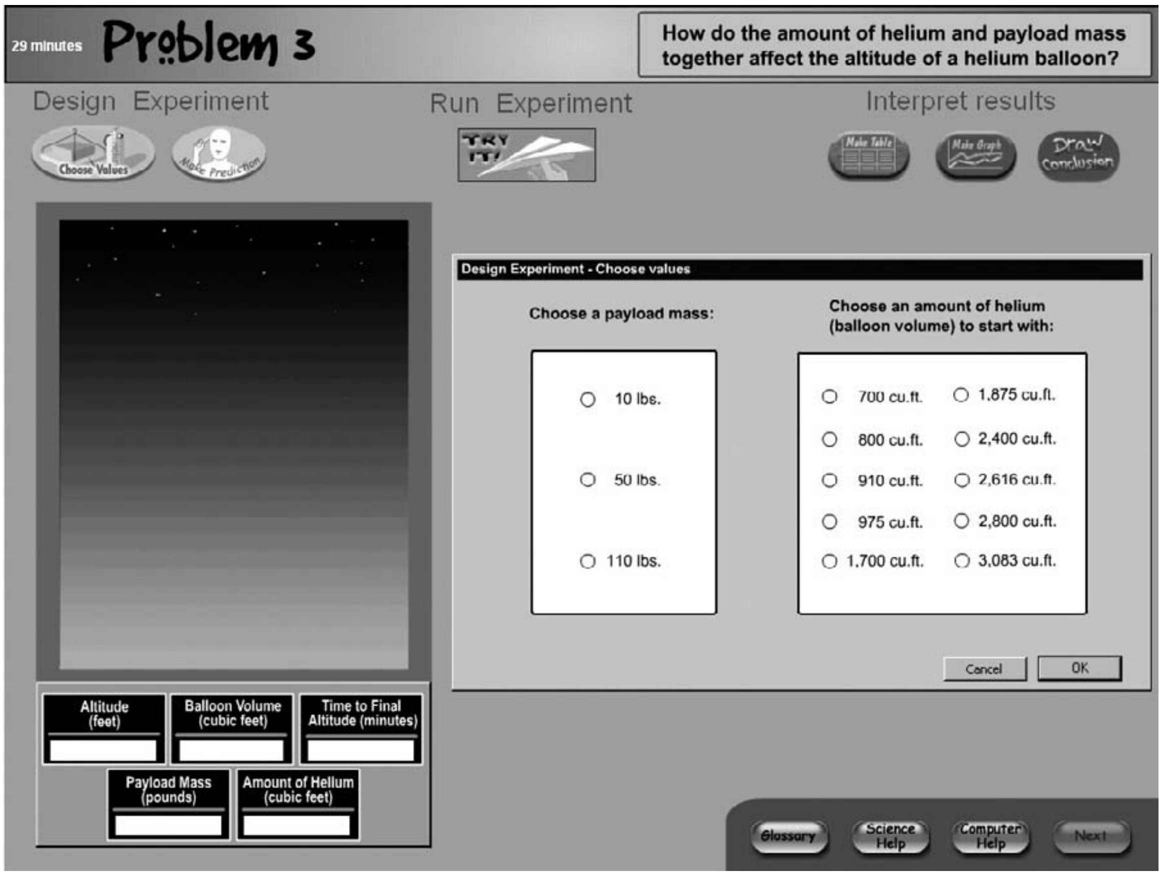
**Figure 1-20.** Computer screen with multiple-choice question on the relationship between altitude and amount of helium in TRE Simulation scenario problem 2, grade 8: 2003




NOTE: TRE = Technology-Rich Environments.
SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2003 Problem Solving in Technology-Rich Environments Study.

Problem 3, the final Simulation problem, was the most conceptually complex, as it required students to discover how payload mass and amount of helium worked together to determine the altitude that the balloon could reach. Thus, students not only had to think about which experiments to run and how many, but they also had to control for one independent variable while manipulating the other. To limit the complexity of the problem, the number of masses students could vary was reduced to three, as shown in figure 1-21.

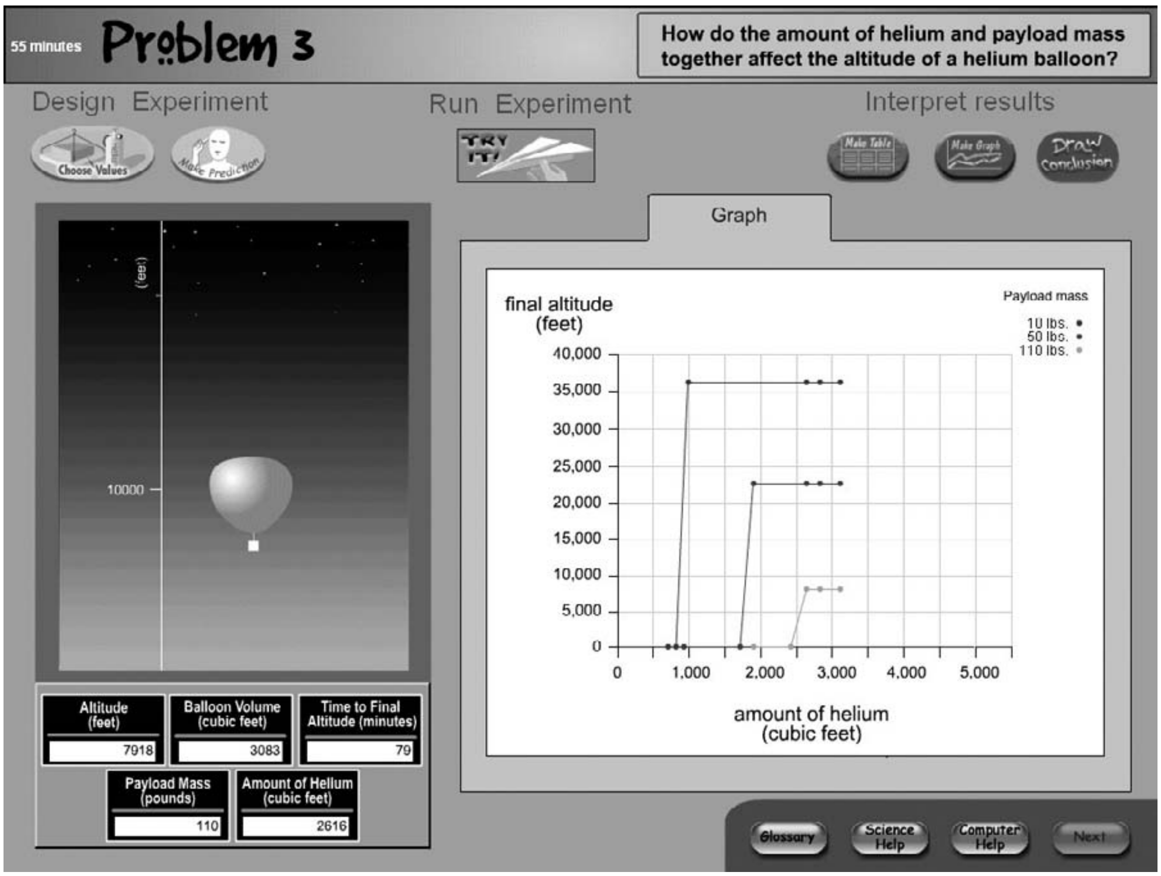
**Figure 1-21.** Computer screen with the dialog box menu of choices for the independent variables in TRE Simulation scenario problem 3, grade 8: 2003




NOTE: TRE = Technology-Rich Environments.
SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2003 Problem Solving in Technology-Rich Environments Study.

In problem 3, students had to discover a nonlinear relationship that took the form of a series of step functions, one for each mass. Figure 1-22 displays what the graph looked like if a student had constructed the correct data display and had run a sufficient number of experiments to reveal all three functions. Note that the maximum altitude for each step function decreased as payload mass increased.

**Figure 1-22.** Computer screen with graph of the relationship of altitude with mass and amount of helium in TRE Simulation scenario problem 3, grade 8: 2003

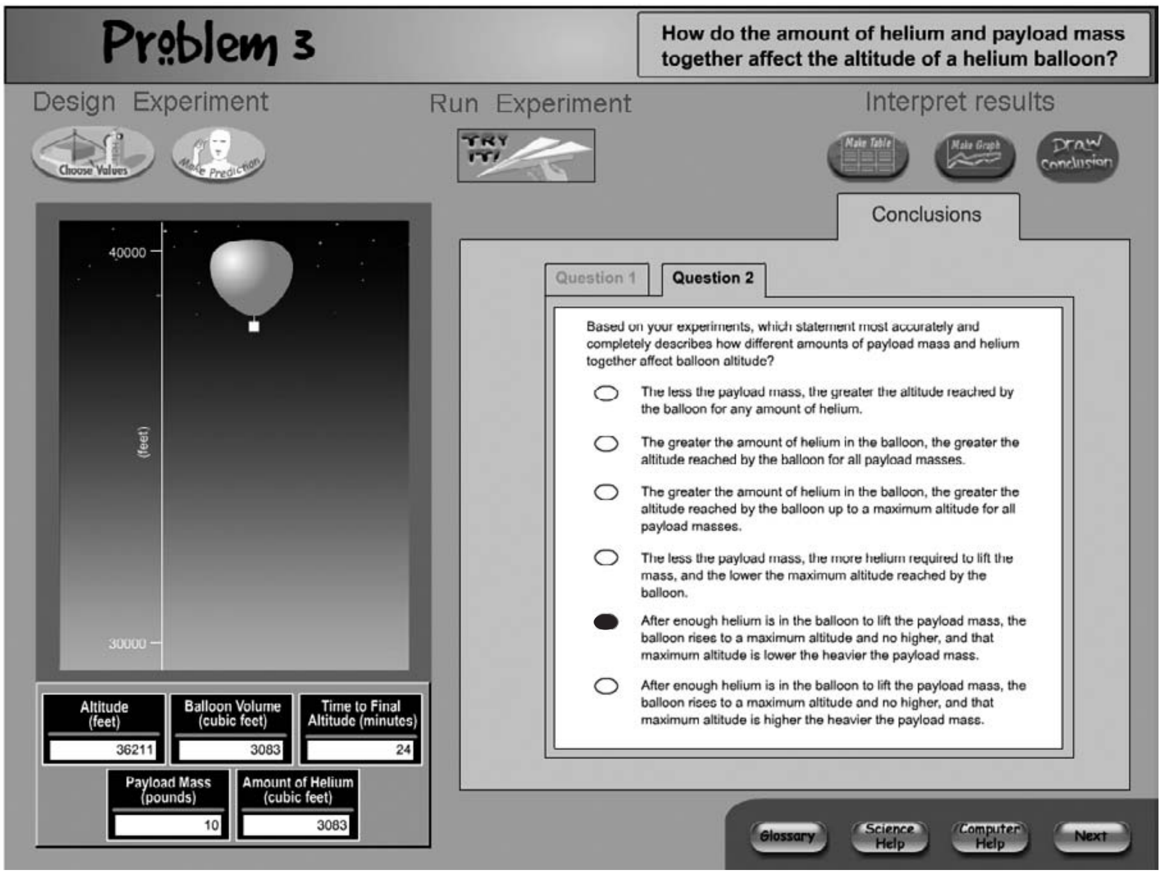



NOTE: TRE = Technology-Rich Environments.

SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2003 Problem Solving in Technology-Rich Environments Study.

After entering a constructed response describing the relationship they discovered, the students were asked to respond to a multiple-choice question intended to probe the same relationship. The question is shown in figure 1-23.

**Figure 1-23.** Computer screen with multiple-choice question on the relationship of altitude with mass and amount of helium in TRE Simulation scenario problem 3, grade 8: 2003

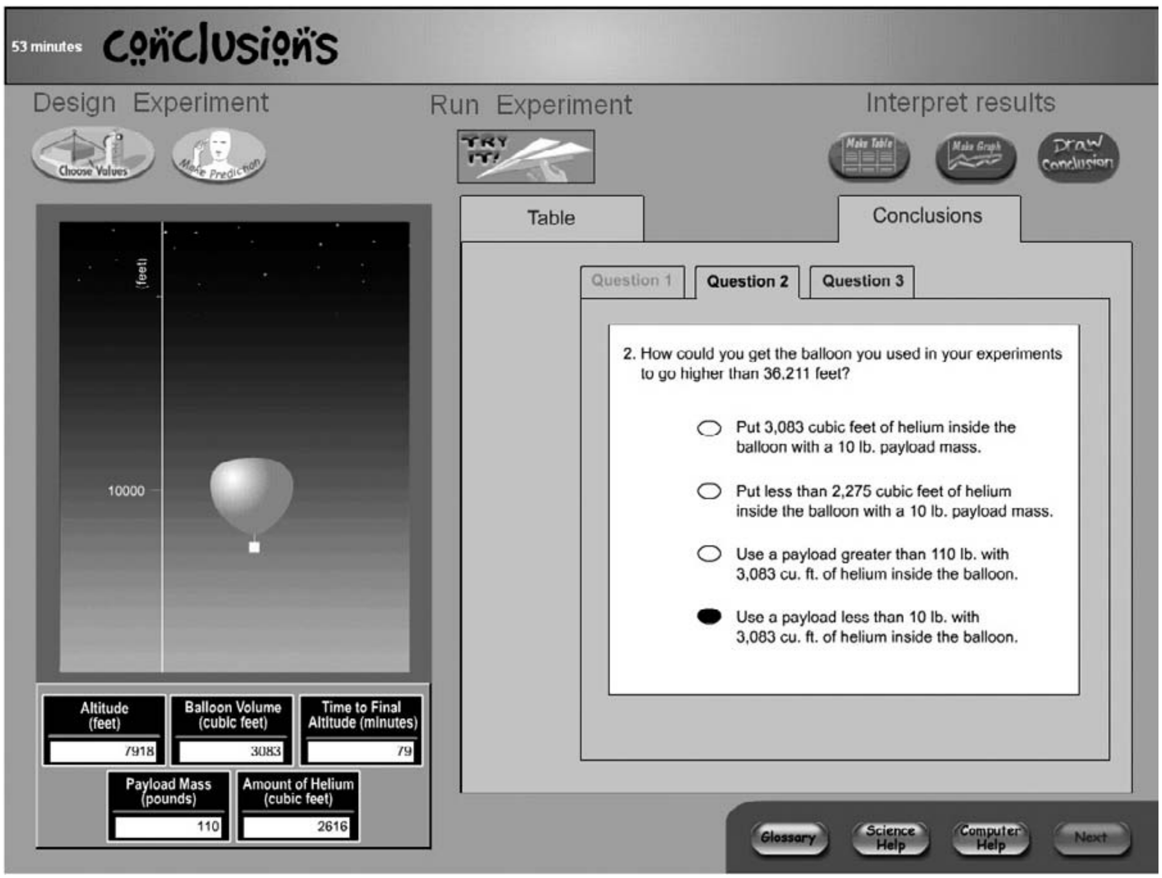



NOTE: TRE = Technology-Rich Environments.
SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2003 Problem Solving in Technology-Rich Environments Study.

When students finished problem 3, they were asked to respond to several multiple-choice questions to see how well they grasped the physics behind the overall Simulation scenario. One of the questions is shown in figure 1-24; the oval next to the correct answer is shaded. To respond to this question, students needed to have grasped that, short of increasing the size of the balloon, the only way to get the balloon to achieve a higher altitude would be to attach a payload mass smaller than any of the masses available to students in the simulation.

After completing these synthesizing questions, students could read an explanation of the physics behind helium balloons, but they could not re-enter the simulation. The explanation was included because the TRE project team believed it was important that students leave the scenario with an accurate description of the science underlying the problems they had addressed. Finally, students responded to background questionnaires, as they had done at the conclusion of the Search scenario.

**Figure 1-24.** Computer screen with one of the multiple-choice questions concluding the TRE Simulation scenario, grade 8: 2003




NOTE: TRE = Technology-Rich Environments.
SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2003 Problem Solving in Technology-Rich Environments Study.