

PART IV

2000 SCIENCE PERFORMANCE TASK

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Following is the Year 2000 performance task. The task serves as a model for teachers and program developers as they design laboratory experiences for students. This and previously released performance tasks, provide a rich bank of open-minded, hands-on, minds-on activities which may be used with middle and high school students in a variety of settings. Effective use of these and similar open-ended tasks involves:

- using tasks as part of planned, ongoing instruction to develop conceptual understanding or reinforce particular skills and concepts;
- using tasks as part of ongoing assessments, aligned with instructional objectives;
- expecting students to work collaboratively;
- focusing on alternative approaches to solving each task; and
- requiring students to explain their reasoning and present their solutions.

Every year, when the CAPT results are announced, the performance task, including rubrics and annotated student work is sent to each school district.

2000 CAPT Science Performance Task

Apple Juice

Apple Tree, Inc. is a company in the business of making and selling apple juice. To make apple juice, apple sauce is strained through filters to remove the juice. The company would like your help in testing different additives, known as enzymes, to determine if they help remove more juice during this process. The following is a list of the enzymes along with their prices:

Pectinase	\$50 per liter
Cellulase	\$100 per liter

Your Task

You and your partner will design and conduct an experiment to determine which enzyme or combination of the two enzymes maximizes juice production and would be most cost effective. During this activity you will work with a partner (or possibly two partners). However, you *must* keep your own individual lab notes because after you finish you will work *independently* to write a report about your investigation.

You have been provided with the following materials and equipment. It may not be necessary to use all of the equipment that has been provided. You may use additional materials and equipment if they are available.

2 containers of apple sauce	2 droppers
Pectinase enzyme	3 stirring rods
Cellulase enzyme	14 labeling dots
4 plastic measuring cups	Graduated cylinder
4 coffee filters	Access to tap water
4 paper cones	Scissors
4 plastic spoons	Ruler
4 paper cups	Access to a balance
4 small plastic cups	Access to a watch or clock with a second hand
Splash-proof goggles and aprons	Paper towels for clean-up

Steps to Follow

- 1. In your own words, clearly state the problem you are going to investigate.** Include a clear identification of the independent and dependent variables that will be studied. Write your statement of the problem on page 4.
- 2. Design an experiment to solve the problem.** Your experimental design should match the statement of the problem, should control for variables, and should be clearly described so that someone else could easily replicate your experiment. Include a control if appropriate.

Note: The enzyme(s) should be well mixed into the apple sauce to be effective. Use 5 to 10 drops of enzyme per 50 grams of apple sauce (approximately two ounces).

Safety note: As in any laboratory experiment, you must not eat or taste any of the materials.

Making a funnel: To make a funnel, cut off the tip of a paper cone approximately 2 centimeters from the bottom. To filter, place the coffee filter paper into the funnel.

Write your experimental design on page 4. Show your design to your teacher before you begin your experiment.

- 3. After receiving approval from your teacher, work with your partner to carry out your experiment.** Your teacher's approval does not necessarily mean that your teacher thinks your experiment is well designed. It simply means that in your teacher's judgment your experiment is not dangerous or likely to cause an unnecessary mess.
- 4. While conducting your experiment, take notes on the attached pages.** Include the results of your experiment. Tables, charts and/or graphs should be used where appropriate and should be properly labeled. Space for your data is provided on page 8.

Your notes will not be scored, but they will be helpful to you later as you work independently to write about your experiment and results. You must keep your own notes because you will not work with your partner when you write your lab report.

When you have finished your experiments, your teacher will give you instructions for clean up procedures, including proper disposal of all materials.

(Students are provided with four blank pages for their notes, as well as a grid for tables, charts or graphs.)

Directions for Writing Your Laboratory Report

Working on your own, summarize your experiment and results. You may use your own notes that you took previously while working with your partner. You may wish to write a first draft of your lab report on scratch paper. Space for your final report is provided on the following pages in this booklet. You will have approximately 30 minutes to complete your report.

Your report should include the following:

- **A clear statement of the problem you investigated.** Include a clear identification of the independent and dependent variables that were studied.
- **A description of the experiment you carried out.** Your description should be clear and complete enough so that someone else could easily replicate your experiment.
- **The results of your experiment.** Tables, charts and/or graphs should be used where appropriate and should be properly labeled. Space for your data is provided on page 15.
- **Your conclusions from the experiment.** Your conclusions should be fully supported by data.
- **Comments about how valid you think your conclusions are.** In other words, how much confidence do you have in your results and conclusions? Any factors that contribute to a lack of confidence in the results or conclusions should be discussed. Also, include ways that your experiment could be improved if you were to do it again.

(Students are provided with four lined pages for their reports, as well as a grid for tables, charts or graphs.)

CAPT Experimentation Questions

Apple Juice

Students in a science class were conducting experiments to study the use of different enzymes on the removal of apple juice from apple sauce.

Group A carried out the following experiment:

1. We placed apple sauce into 3 separate plastic cups. We labeled the cups X, Y, and Z.
2. Then we added 10 drops of pectinase into cup X, 10 drops of cellulase into cup Y, and 5 drops of pectinase and 5 drops of cellulase into cup Z.
3. We then stirred each of the mixtures.
4. We filtered each of the 3 cups of apple sauce with enzymes using a coffee filter, paper funnel, and cup to collect the juice.
5. We measured the amount of apple juice that was filtered from each mixture.

Our results are shown below:

Cup	Amount of Enzyme	Amount of Apple Juice Collected
X	10 drops pectinase	24 mL
Y	10 drops cellulase	17 mL
Z	5 drops of each enzyme	25 mL

1. This is Group A's statement of the problem that they were investigating: "We wanted to find out how enzymes remove apple juice from apple sauce." Is this a clear statement of the problem? Explain fully why or why not.
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2. What are the variables that need to be controlled in **Group A's** experiment? Explain why it is important to control them.

Group B carried out the following experiment:

1. We took four plastic cups and added 30 grams of apple sauce to each one
2. In cup A we added 1 drop of pectinase, in cup B we added 4 drops of pectinase , in cup C we added 7 drops of pectinase , and in cup D we added 10 drops of pectinase.
3. We stirred the apple sauce and enzyme in each cup.
4. We then filtered each of the mixtures and collected the apple juice.

The table below shows their results.

Cup	Amount of Pectinase	Amount of Apple Juice Collected
A	1 drop	4 mL
B	4 drops	10 mL
C	7 drops	12 mL
D	10 drops	15 mL

3. Draw a graph of Group B's results. Be sure to label your graph.

4. What conclusions can be drawn from Group B's experiment? Explain how valid you think these conclusions are based on the group's experiment and results.

Apple Juice

Item 1

This item assesses a student's understanding of what constitutes a well-defined problem for an experiment. Group A's statement of the problem is not clear, because the group was not testing *how* the enzymes removed apple juice from apple sauce. Group A was comparing the ability of different enzymes to help remove apple juice from apple sauce. According to their experimental design, Group A's independent variable was the type of enzyme (pectinase, cellulose, or combination of the two enzymes). Their dependent variable was the amount of apple juice collected.

CAPT Framework

Experimentation: Define the problem.

Item 2

This item assesses students' understanding of what constitutes an appropriate experimental design. There are several variables that are important to control including, the amount of apple sauce and enzymes and the type and time of certain treatments of the apple sauce and enzyme mixture (i.e., stirring, filtering, and sitting).

It is important to control these variables so that the independent variable (type of enzyme) can be isolated and tested in the experiment.

CAPT Framework

Experimentation: Design and conduct appropriate experiments.

Item 3

This item assesses a student's ability to draw an appropriate graph from given data. Either a line or bar graph may be appropriate for the data shown. For either graph, proper labeling of axes, including units, and accurate plotting of the data points are important. For line graphs, proper scaling of the axes is also important.

CAPT Framework

Experimentation: Make, record and interpret observations.

Item 4

This item assesses a student's ability to draw a conclusion based on the results of an experiment and to discuss the validity of this conclusion. The conclusion that might be drawn from Group B's results is that as the amount of pectinase added to apple sauce increases, the amount of apple juice collected also increases.

The validity of the conclusion should be questioned because only one trial was carried out. It is also not known if important variables were controlled in the experiment (e.g., amount of stirring, time for filtering). Water also should have been added to each cup to control for the total amount of liquid added to each cup (i.e., nine drops of water to Cup A, six drops of water to Cup B, three drops of water to Cup C).

CAPT Framework

Experimentation: Draw conclusions and discuss their validity.

Scoring Rubric for Open-Ended Items

Each score category contains a range of student responses which reflect the descriptions given below.

Score 3

The response is an excellent answer to the question. It is correct, complete, and appropriate and contains elaboration, extension, and/or evidence of higher-order thinking and relevant prior knowledge. There is no evidence of misconceptions. Minor errors will not necessarily lower the score.

Score 2

The response is a proficient answer to the question. It is generally correct, complete, and appropriate although minor inaccuracies may appear. There may be limited evidence of elaboration, extension, higher-order thinking, and relevant prior knowledge, or there may be significant evidence of these traits but other flaws (e.g., inaccuracies, omissions, inappropriateness) may be more than minor.

Score 1

The response is a marginal answer to the question. While it may contain some elements of a proficient response, it is inaccurate, incomplete and/or inappropriate. There is little if any evidence of elaboration, extension, higher-order thinking or relevant prior knowledge. There may be evidence of significant misconceptions.

Score 0

The response, although on topic, is an unsatisfactory answer to the question. It may fail to address the question, or it may address the question in a very limited way. There may be no evidence of elaboration, extension, higher-order thinking, or relevant prior knowledge. There may be evidence of serious misconceptions.