ASPECt
Assessing Students' Progress on the Energy Concept

Coolants: AP03-6

Middle School – Thermal Energy

TASK OVERVIEW

Students are introduced to an experiment designed to see which engine coolant is more effective at preventing a car's engine from heating up. Students are provided with the experimental procedure and results from the experiment, and then they are asked to identify possible explanations for the experiment's results and what issues there are in its design. Lastly, students are asked to revise the experimental procedure so that the appropriate variables are either controlled or allowed to vary.

TARGETED DCIs, SEPs, AND CCCs

Disciplinary core ideas

- PS3.B-M.2: The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment.

Science & engineering practices

- SEP3-M.1: Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.

- SEP3-M.2: Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation.

Crosscutting concepts

- None

Related Performance Expectations

- MS-PS3-4. Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. [*Clarification Statement*: Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the same material with different masses when a specific amount of energy is added.] [*Assessment Boundary*: Assessment does not include calculating the total amount of thermal energy transferred.]

TASK PERFORMANCE EXPECTATION

Identify plausible explanations of experimental data on temperature changes for two substances. *Identify dependent and independent variables* in an experiment and revise the experiment's procedure to make a controlled experiment.

LINK TO ONLINE VERSION

http://assess.bscs.org/i/test/607

Task

When a car's engine is running, the engine can get extremely hot, so a liquid coolant is used to help cool the engine.

An engineer is studying two different coolants. He would like to know which of the two is a better coolant. A good coolant is one that has only a small temperature increase when it is heated. To help him figure out which coolant is better, he sets up an experiment. The procedure for the experiment is below:

Step 1: Pour each coolant into a separate metal container.

Step 2: Measure the temperature of the coolant in each container using a thermometer.

Step 3: Heat each coolant on the stove at the same heat setting.

Step 4: Measure the temperature of each coolant after it has been heated.

He records his temperature measurements in a table.

Temperature data from the Investigation

	Coolant A	Coolant B
Before being heated	15 °C	15 °C
After being heated	51 °C	94 °C

The engineer thinks Coolant A is better than Coolant B. Another engineer points out that his conclusions may not be correct because the test of the coolants may not have been fair. There could be several other ways to get the same results shown in the table.

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1. The engineers decide to list some reasons why the two coolants could have different temperatures after they were heated. For each of the responses below select yes or no to indicate whether or not the reason listed could explain why two coolants have different temperatures after they are heated.

A. If coolants are made of different substances, they could have different temperatures after being heated.	Yes	No
B. If coolants have different masses, they could have different temperatures after being heated.	Yes	No
C. If coolants are heated for a different length of time, they could have different temperatures after being heated.	Yes	No

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Now, it's your job to design an experiment to figure out which coolant has the smallest temperature increase when it is heated.

2. What should vary in your experiment and what should be held constant? Select a response for each.

	Should vary	Should be held constant
A. The mass of the coolants		
B. The length of time the coolants are heated		
C. The type of coolants		
D. The temperature of the coolants before being heated		

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3. Based on your answers to the previous questions, what revisions need to be made to the engineer's procedure?

Alignment to Targeted DCIs, SEPs, and CCCs and Scoring Rubrics

QUESTION 1

The engineers decide to list some reasons why two coolants could have different temperatures after they are heated. For each of the responses below select yes or no to indicate whether or not the reason listed could explain why two coolants have different temperatures after they are heated.

A. If coolants are made of different substances, they would have different temperatures after being heated.	Yes	No
B. If coolants have different masses, they would have different temperatures after being heated.	Yes	No
C. If coolants are heated for a different length of time, they could have different temperatures after being heated.	Yes	No

LEARNING GOAL

Learning Performance

- Evaluate an experiment's design and results to identify possible explanations for why a certain result were obtained.

Targeted DCIs, SEP, and CCC

- PS3.B-M.2 The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment
- SEP3-M.2 Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation.

SCORING RUBRIC

Elements of a Correct Response

Categories	Elements
Student selects the correct response to the multiple-choice options	• Yes to all answer choices.

QUESTION 2

What should vary in your experiment and what should be held constant? Select a response for each.

	Should vary	Should be held constant
A. The mass of the coolants		
B. The length of time the coolants are heated		
C. The type of coolants		
D. The temperature of the coolants before being heated		

LEARNING GOAL

Learning Performance

- Identify which variables in an experiment should vary based on what the intended goals are for the experiment.

Targeted DCIs, SEP, and CCC

- PS3.B-M.2 The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment
- SEP3-M.1 Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.

SCORING RUBRIC

Elements of a Correct Response

Categories	Elements
Student correctly identifies what should vary and what should be controlled	• Should vary for "The type of coolants" • Should be held constant for all other answer choices

QUESTION 3

Based on your answers to the previous questions, what revisions need to be made to the engineer's procedure?

LEARNING GOAL

Learning Performance

- Revising an experimental design so external variables are controlled.

Targeted DCIs, SEP, and CCC

- PS3.B-M.2 The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment (Students maybe using this to determine which variables need to be held constant)
- SEP3-M.2 Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation.

SCORING RUBRIC

Ideal Response

In Step 1 the engineer should pour an equal amount by mass of each substance into separate metal containers. In Step 3 when they heat each substance on the stove, they should heat each substance the same amount of time.

Elements of a Correct Response

Categories	Elements
Student describes a fair test	• Equal masses of each coolant should be used in Step 1 [Note: Saying there must be the same amount of each coolant is acceptable.] • The coolants should be heated for the same amount of time in Step 3 Note: If the student explains that everything needs to be the same except the coolants, they get both points. They do not get the points if they say "everything needs to be the same."

Sample Student Responses

Student response	Scoring description
"He needs to get to different cars and pour coolant into the two different cars."	Score = 0 The response introduces a new variable that would not make it a fair test.
"The engineer should measure out the coolants to ensure the mass stays the same."	Score = 1 The response includes one revision that would help make the experiment a fair test.
"The amount of coolant needs to be a constant. The period of time in which the coolants are heated need to be a constant as well. I think the rest of the experiment is ok."	Score = 2 The response includes both elements in the rubric.

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