# Pattern Analysis of Student Thinking (PAST)
# HS-PS2-6: It's the Little Things That Matter Formative Assessment Task

**PE: Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.**

**DCI – Types of Interactions:**
Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.

## TASK 1 – *Energy Transfer Model*

| Purpose | Student Response Themes | Examples of Student Responses | Possible Teacher Instructional Moves |
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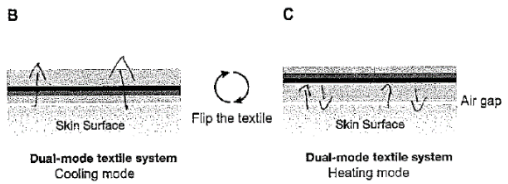
| This task is designed so that students can construct an explanation and complete a model to communicate their thinking about how a new reversible fabric interacts with thermal energy to heat or cool the body depending on the fabric orientation. | **Question 1**<br>Student revised a model to describe how thermal energy is reflected by one layer to heat the skin and emitted in the other layer to cool the skin depending on the orientation of the layers. |  | Have students compare and contrast their models. As a whole group share how their models were similar and different. Have a consensus making discussion so that the whole class comes to a general agreement for how energy would be reflected or transferred in each scenario. Have students construct models for how ordinary fabrics absorb or reflect thermal energy. |
| | **Question 2**<br>Student constructed an accurate explanation for their model and described how in the cooling mode thermal energy is transferred away from the skin and emitted away from the body while in heating mode thermal energy is reflected back to the skin. | *The dual-mode cooling mode is meant to keep you cool. In this mode the heat rapidly travels through the polymer layer and ends up being emitted to the surrounding by the bilayer. In the heating mode it is meant to keep you warm. This is done by flipping the layer over so that the bilayer reflects heat back to the body and the thick polymer layer hinders conduction by providing an air gap.* | |

**Focus SEP/CCC:**
Students develop a model to explain how thermal energy transfer might occur in two different orientations of a reversible fabric.

## TASK 2 – *Carbon and Copper Molecular Structure*

| Purpose | Student Response Themes | Examples of Student Responses | Possible Teacher Instructional Moves |
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| This task is designed so students make observations of the molecular structure of carbon and copper and relate how their molecular structure could affect how they function in relation to thermal energy transfer. | **Question 3**<br>Student made observations about the characteristics of the carbon layer. | ● *Up close it looks like a sponge with lots of gaps.*<br>● *The layers are somehow packed together and connected together in a rigid structure. However, there are still gaps between the connections.* | Have students share their observations and make a class list of the observations for each material. Facilitate collaborative discussions about how the observed characteristics might help explain how they function. Provide other examples of how these materials are used based on their molecular structure (ex. carbon fiber, copper wire or copper cookware).<br>Provide opportunities for students to make firsthand observations of materials made from carbon and copper. Student could conduct simple investigations using these materials to determine how they react to thermal energy. |
| | **Question 4**<br>Student explained how the molecular structure of the carbon layer affects it appearance to the naked eye. | ● *The molecular structure looks densely packed together. This might be why it looks dark and smooth to the naked eye.*<br>● *All the carbon atoms connected together the way they are make it look fuller as a piece of carbon fabric.* | |
| | **Question 5**<br>Student explained how the molecular structure of the carbon layer might affect how it reacts to thermal energy. | ● *The openings in the carbon structure help let the heat out so that it doesn't absorb or retain heat.*<br>● *It's rather open so rather than holding in heat, it has room to allow the heat to be reflected back.* | |

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| **Question 6**<br>Student made observations about the characteristics of the copper layer. | ● *It is very solid with few openings or chambers.*<br>● *The atoms are all connected tightly to each other.* | |
| **Question 7**<br>Student explained how the molecular structure of the copper layer affects it appearance to the naked eye. | ● *Very solid looking with no openings just like the shiny copper layer.*<br>● *The copper would look smooth because the atoms are laying down close to each other in strands.* | |
| **Question 8**<br>Student explained how the molecular structure of the copper layer might affect how it reacts to thermal energy. | ● *The copper probably conducts heat well because all the atoms are touching each other very closely.*<br>● *The way the atoms are close together could mean that heat can move through the atoms more easily.* | |

**Focus SEP/CCC:**
Students use a model of the molecular structure of carbon and copper to predict how the molecular structure might affect how it interact with thermal energy transfer.

| TASK 3 – *Explaining Structure and Function of Nanomaterial Fabric* | | | |
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| **Purpose** | **Student Response Themes** | **Examples of Student Responses** | **Possible Teacher Instructional Moves** |
| This task is designed for students to apply the concepts of thermal energy transfer such as conductance and reflection along with knowledge of molecular structure to explain how a proposed reversible fabric could both heat and cool the human body. | **Question 9**<br>Student constructed a logical explanation for how the carbon and copper layer work together to either reflect or absorb heat depending on how they are oriented to the skin. | *The heat rapidly travels through the polymer to the carbon/copper bilayer. When the copper is facing down it absorbs heat from the skin and transfers it to the carbon layer which emits the heat away from the body keeping the body cool. When the carbon layer is down heat is reflected and emitted back toward the skin to keep it warm.* | Have students work in small groups to collaboratively apply what they have learned through previous investigations or personal experience with carbon and copper to explain how the reversible fabric utilizes these properties to heat or cool. Have student share their explanations with other groups so that they can strengthen or revise their thinking. Have student go back and revise their explanations for how the reversible fabric functions. . |
| **Focus SEP/CCC:**<br>Students read and synthesize information from scientific text and models to construct an explanation for how a carbon/copper dual layer reversible fabric can utilize the molecular structure of these elements to reflect or absorb thermal energy. | | | |


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