Conservation and Transformation of Energy
PS-6 The student will demonstrate an understanding of the nature, conservation, and transformation of energy.

PS-6.6 Explain the relationships among voltage, resistance, and current in Ohm's law.
Taxonomy Level: 2.7-B Explain Conceptual Knowledge

Key Concepts:

Voltage	Volt
Resistance	Ohm
Current	Ampere
Ohms law	

Previous/Future knowledge: In the 4th grade students summarized the functions of the components of complete circuits (including wire, switch, battery, and light bulb) (4-5.6), and also illustrated the path of electric current in series and parallel circuits (4-5.7). In the 6th grade students illustrate energy transformations (including the production of light, sound, heat, and mechanical motion) in electrical circuits (6-5.4). In Physical Science students will expand their concepts of the relationships among current, voltage, and resistance in the context of Ohm's law.

It is essential for students to understand that

- ***Voltage*** is electric potential energy per charge. It provides the energy that pushes and pulls electrons through the circuit.
  - Voltage is measured in *volts*. The symbol is (V).
  - Voltage is created by:
    - a chemical cell when it changes chemical energy to electrical energy, or
    - by a generator when it changes mechanical energy to electrical energy, or
    - by a solar cell when it changes light energy to electrical energy.
- When a wire connects the terminals of a battery or generators, then the *voltage* will push and pull electrons through a conductor.
  - One terminal has extra electrons thus a negative charge. The other terminal has a deficit of electrons and thus a positive charge.
  - Electrons in the wire are pushed by the negative terminal and pulled by the positive terminal through the wire.
- ***Electric current*** is the flow of charge through a conductor.
  - The electric current in a wire is the flow of electrons.
  - Electric current is measured in *amperes* or amps. The symbol is (A).
- Electric ***resistance*** opposes the flow of charge through a conductor. All conductors have some resistance to an electric current with the exception of some superconducting materials at very low temperatures.
  - In wires, resistance occurs when the electrons flowing through the wire continually run into metal atoms and bounce around. These collisions impede the flow of the electric current and change some of the electrical energy to thermal and/or light energy.
  - Resistance is measured in *ohms*. The symbol is (Ω).
  - Resistance will reduce the flow of current because it is harder for the current to get through the conductor.
    - When an electric current encounters resistance heat is produced.
    - Wires that have a larger diameter have less resistance.
    - Longer wires have greater resistance.

    - In many materials an increase in temperature will increase resistance.
  - Electric devices provide much of the resistance in a circuit.
- ***Ohms law*** describes the relationship between voltage, current, and resistance.
  - The voltage (V) is the product of the current (I) and resistance (R). (V = I R)
  - One volt will pull one amp of current through one ohm of resistance.
  - If the voltage increases and the resistance remains the same, the current will increase.
  - If the voltage stays the same and the resistance increases, then the current will decrease.

It is not essential for students to know
- The number of electrons in a coulomb;
- The term electromotive force or potential difference;
- About superconductors;
- About resistivity of materials.

Assessment Guidelines:
The objective of this indicator is to *explain* the relationship among voltage, resistance, and current in Ohm's law, therefore, the primary focus of assessment should be to construct cause and effect models showing these relationships.

In addition to *explain*, assessments may require that students
- *Compare* the concepts of voltage, current, and resistance;
- *Summarize* major points about voltage, current and resistance;
- *Infer* what will happen when one of the variables changes.