Research on Student Learning

Before instruction, many elementary- and middle-school students are not aware of the bipolarity of batteries and light bulbs; do not recognize the need for a complete circuit to make a bulb light; and do not succeed in making a lamp light when given a battery and a number of connecting wires. [1] However, many high-school and university students also fail at this task. [2] This suggests that they also do not understand or cannot apply the concept of a complete circuit. [3] Teaching sequences that take account of students' ideas can help middle-school students make progress in this area. [4] Students of all ages have difficulty reasoning that all parts of a circuit are interrelated and influence each other. Instead, they think of circuits in terms of electric current traveling around the circuit meeting each component in turn. They think of a change in the circuit affecting only those components that come after the change. This "sequential" reasoning underlies many problems that students have in understanding electric circuits and is highly resistant to change. [5]

Students tend to start instruction with one concept for electricity in electric circuits which has the properties of movement, storability, and consumability and which students label "current," "energy," or "electricity." [6] Even after instruction, many students of all ages do not differentiate bewteen electric current and electric energy. They also tend to think that the battery is the source of the current and that the circuit is initially empty of the stuff that flows through the wires. [7] Many students after instruction believe that a battery releases the same amount of current regardless of the circuit to which it is attached, that the fixed current flows out of the battery and diminishes every time it goes through a circuit element that uses up the current, so that there is less current at the end of the circuit. [8] These beliefs are highly resistant to change. [9] Identifying energy as the quantity that is dissipated can help students reconcile their intuitive belief that something is used up in circuits with the formal knowledge that electric current is conserved. [10]

Little is known about students' reasoning about the microscopic mechanisms that underlie electric current and their interpretation in terms of electrostatic entities. After instruction, high-school students may not be inclined to or, when prompted, may have difficulties relating macroscopic parameters (such as electric current) to microscopic processes and electrostatic interactions (such as forces on charged electrons). [11] Students may think of the battery as the only source of electrons which move in the circuit, i.e., the battery releases electrons into the wires which play no active role; They may also think of electrons moving through a circuit as single unconnected particles moving around. [12]

Elementary-school students are usually aware of the behavior of magnets but may not explain the behavior in terms of forces (i.e., they may think of a magnet sticking to or moving towards another magnet but may not recognize this as the effect of a pull or force). [13] Students of all ages may think of gravity and magnetism interchangeably. They may refer to magnetism as a "type of gravity," but they may also explain gravity in terms of the earth acting like a magnet on objects. Students may think that magnets do not work in a place where there is no air, just like they think about gravity. [14] Students of all ages may also confuse electrostatic and magnetic effects. [15] For example, they may predict that north magnetic poles repel positively charged objects. [16]

Students do not readily recognize the magnetic effect of an electric current. Some think of the wire, rather than the electric current as being the cause of the magnetic effect. Students may think that insulation around the wire prevents the existence of magnetic forces when current flows. [17]

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