Mindbugs are Misconceptions

Bug-Busters are intended to address widespread gaps in student understanding, the MindBugs of math and Science.

A MindBug began life as a simple misconception but grew rapidly out of control. A child learns to line numbers up to the right and add; this procedure works until 5th grade when decimals appear on the scene.

MindBugs are found in every student in every school in America. The goal of the MindBugs and Bug-Buster series is to eradicate those misconceptions. Erase the problems brought on by shallow procedural knowledge, and build a deeper foundation based on core conceptual understanding.

Addressing MindBugs: Building a Strong Foundation in Math and Science

Misconceptions in learning—what we call *MindBugs*—can start small but quickly grow into obstacles that impede deeper understanding. A MindBug often begins as an innocent misunderstanding or an overgeneralization of a rule, like lining numbers up to the right to add. While this approach works for simple math, it falls apart when decimals or complex scenarios enter the picture. Over time, unchecked MindBugs can solidify into gaps in knowledge that make future learning challenging.
MindBugs are pervasive. Every student, in every classroom across the country, carries with them some level of misunderstanding in math or science. Left unaddressed, these misconceptions not only hinder progress but also undermine confidence and curiosity—critical components of STEM success.

This is why the **MindBug Busters** series exists. Through engaging cards and activity books, we identify and address these misconceptions head-on. By eradicating shallow procedural knowledge, MindBug Busters help students rebuild their understanding from the ground up, focusing on core concepts and true mastery.
The process is critical. Misconceptions often form because students are taught procedures without fully grasping the "why" behind them. By exposing and correcting these gaps, MindBug Busters ensure students aren't just following steps—they're understanding the principles that drive problem-solving in math and science.

The ultimate goal of the MindBug and Bug-Buster activities is transformation: to take students from a surface-level approach to learning and guide them toward a deeper, more resilient foundation of knowledge. By addressing these misconceptions early, we empower students to grow into confident learners and innovative thinkers, prepared for the challenges of the future.

"AA Batteries should weigh less after they've been used!"

Batteries do not "use up" their energy by burning battery acid like gasoline in an automobile. Batteries operate using chemical reactions that produce electrons. An alkaline battery like the AA has two terminals: one end is marked (+) positive and one end is marked (-) negative.

Electrons collect on the negative terminal of the battery. They flow from the negative terminal through a wire-connected load to the positive terminal. Your load might be a light bulb or remote control.

MindBug corrected herself and explained correctly:

Electrons move through wire from the negative terminal to the positive terminal of the battery, where electrons are removed from the wire. More electrons build at the negative terminal. A chemical reaction continues to "pump" electrons from the negative terminal to the positive terminal... so a charge doesn't get "used up." Once reactants are done, no more electrochemical reaction takes place.

This week, weigh a set of AA batteries before placing them in a remote control vehicle. Run the vehicle until the batteries "run out." Then, remove batteries from the toy and reweigh them to prove that reactants and electrons are not depleted during use.

As of November 2024, the latest advancement in publicly available battery technology is the semi-solid-state battery. This innovation combines the high energy density of solid-state batteries with the safety and manufacturing benefits of traditional liquid electrolytes. Notably, Nio, a leading electric vehicle manufacturer, has introduced a 150 kWh semi-solid-state battery pack developed in collaboration with WeLion. This battery offers a 50% increase in energy capacity compared to conventional packs, with only a minor weight increase, enabling ranges of up to 1,050 kilometers in vehicles like the ET7 sedan. WIKIPEDIA This development marks a significant step forward in battery technology, providing consumers with longer-lasting and more efficient energy storage solutions.

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~~"A light bulb gives off light because the electrons come out of (are emitted from) the bulb."~~

Science errors that stem from dogma are the most difficult to correct. This Science MindBug is something the student was told, an unsubstantiated statement, they could not have seen or experienced electrons leaving a light bulb along with emitted light. It is essential to counter dogma errors with physical experiment.

A current running through wire wound into a coil about an iron object (nail) will deflect the needle of a compass.

Conduct an experiment with a DC circuit which includes a light bulb, and by making an electro-magnet at many places around the circuit, demonstrate that the current is completing the circuit, it has the same strength everywhere in the circuit.

Measure Bug corrected herself and explained the problem correctly:

If the electrons leave the circuit through the light bulb then there's nothing returning to the battery; thus, one could cut the wire between the light bulb and the battery and the light bulb would still light up: which it does not.

A complete circuit (circle) is necessary to make a light work; current only flows in a complete circuit, and it is the resistance to the current flow which produces heat and light.

<u>Start</u> with a simple problem, something the student can see: the brightness of a light is roughly proportional to the current flowing through the bulb. With the same power supply place various resistances in the circuit and measure the brightness of the bulb.

As of November 2024, the latest advancement in light bulb technology is the integration of quantum-dot LEDs (QLEDs) and microLEDs, offering superior brightness, energy efficiency, and color accuracy. Quantum-dot LEDs utilize nanoscale semiconductor particles to emit precise wavelengths of light, resulting in vibrant colors and high luminous efficacy. Recent developments have optimized charge injection in QLEDs, achieving ultra-high brightness levels suitable for lighting and display applications.

Simultaneously, microLED technology has progressed, with companies like Samsung and LG introducing microLED displays that provide exceptional contrast and energy efficiency. Wikipedia

These innovations are transforming the lighting industry, offering consumers more efficient and visually appealing illumination options.

~~"Trees get most of their water through their leaves."~~

The absorption of water through leaves assists in photosynthesis but provides a small portion (5-10%) of the water required by the plant.

Transpiration or loss of water from leaves actually provides the PULL needed to bring water upwards from its source. It moves through thin **xylem** vessels up through the trunk of the tallest trees and the stems of the smallest plants because of the stickiness (**cohesion)** of water molecules.

MindBug corrected herself and explained correctly:

Leaves absorb some water but not enough to keep the plant or tree alive. Most of the water enters a tree or plant at the root system and is transported by capillary action upward. Water later leaves the plant through the leaves (transpiration).

Place 3 short celery sticks (one each with a few leaves, lots of leaves and no leaves) in a small dish with a few centimeters of water & food coloring. Compare the rate of absorption based on leaves & observe water movement over 24 hours.

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Even the best pumps can only pull water upward to about 32 feet before water molecules lose cohesion (stickiness) and the column breaks down. Yet, a group of Arizona scientists determined that no tree can grow taller than 130 meters (427 feet). How can such a tall tree move water from its ground source to its leaves? It turns out that water can be pulled up much farther, provided that it is in a very fine tube. In a capillary tube such as the xylem of plants, the adhesion of the water to the walls fueled by the pull of water loss through leaves (transpiration) helps move water upward through the column.

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"Rainbows and prisms have 7 colors. You know...ROY G BIV."

Truthfully, there are a LOT more than 7 colors in the rainbow. Between yellow and green, there are more shades of yellow-green and between yellow-green and green there are even greener shades of yellow-green and so forth. "ROY G BIV" does help us keep the progression of wavelengths straight, but it does NOT name all the colors in a rainbow.

MindBug corrected herself and explained correctly:

Red, orange, yellow, green, blue, indigo and violet are the 7 wavelengths. "ROY G BIV" helps us recall the 7 wavelengths in their correct order, but we should remember that the visible light spectrum contains a continuum of color within each of those wavelengths.

This week, visit a wavelength applet and give students time to compare frequencies of various wavelengths in the electromagnetic spectrum.
www.lon-capa.org/~mmp/applist/Spectrum/s.htm

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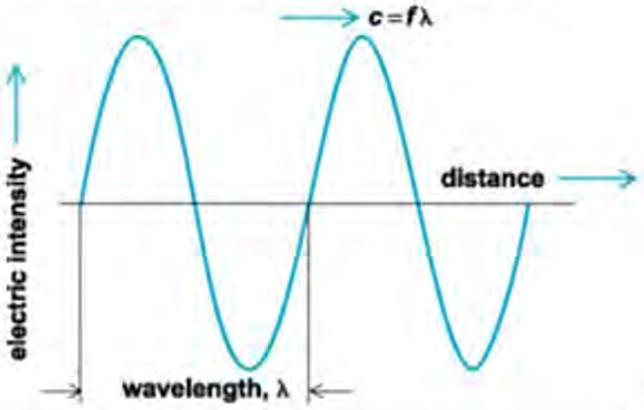
Wavelength is described as the distance between two corresponding points on any two consecutive waves. For visible light, this distance is small and typically measured in nanometers.

Red light has relatively long waves, in the range of 700 nm (10^{-9} meters) long. Blue and violet light have short waves, around 400 nm. Shorter waves vibrate at higher frequencies with higher energies.



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"Air doesn't weigh anything! Neither does a scrap of paper!"

Look at a digital scale. It reads 0 when only air or very small objects are weighed. Students often draw incorrect conclusions because their measuring instruments are not sufficiently sensitive for the investigation. A few simple tools can demonstrate that air does indeed have weight. You might use a bike pump or simple hand pump to double the air pressure in a 2-liter soda bottle. The maximum weight will increase by approximately 1.4 grams.

MindBug corrected herself and explained correctly:

0 + 0 = 0. If you add a piece of paper that weighs 0 to another piece which weighs 0, the sum should still be 0. No matter how many 0's you add, the sum is still 0. But we know a ream of paper has more than 0 weight! I think our scale is just not sensitive enough to weigh this object.

This week, measure the weight of 100 pieces of paper. Then divide that by 100, then cut the paper in half, cut the half in half, etc., until you arrive at the weight of a very small piece. Finally, compare the weight of sports balls before and after inflation..

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At 70 degrees Fahrenheit, a cubic foot of normal pressure sea level air weighs almost 1 1/4 ounces or .075 lb. or .034 kg. When air is heated as in a hot air balloon, the hot air weighs less than the surrounding air and the balloon rises.

Air pressure (14.7 lbs force / cubic inch) is not the same as weight. Another way to show that air has weight is to hang two balloons from opposite ends of a balance. Gently pop one balloon and observe how the balance moves.

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