

CHILDREN'S ALTERNATIVE CONCEPTIONS IN SCIENCE

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This list has been assembled from both the literature and 17 years of exploring the views of my students and collaborating with other science teachers interested in this area. It was written as part of the planning for a forthcoming book, "Teaching For Quality Learning In Science." (I. Mitchell & R. Atkins)

Points to remember

- All of these views are likely to be found in some children in any K-12 school, but it is certainly not true that all of them will be held by all or most students.
- Some are mutually contradictory, e.g., the same student would be most unlikely to believe that gravity is both much weaker and much stronger on top of a tall building. HOWEVER,
- Students can, and often do, give explanations for different situations that are inconsistent and irreconcilable.
- Most of these views are fairly (or very) persistent from K to 12, but some (e.g., views on living) are much less prevalent by middle secondary years.

Broadly Physical Science

1. Energy

- (a) Energy is primarily associated with humans or animals: only humans (or animals) can HAVE energy.
- (b) (The various forms of) potential energy are not a FORM of energy, they describe the potential to gain energy in the future.
- (c) Energy appears (from no energy) during processes such as combustion.
- (d) Sound and/or light are not forms of energy.
- (e) It takes energy to heat up a cup of cold water, (or get a stationary ball rolling), or lift a box up onto a shelf, but the cup of hot water or the rolling ball or the high box do not now HAVE more energy i.e. it takes energy to

MAKE a change to an object but that energy is not still present in the object.

- (f) More generally, most students have a considerably more restricted view of what is included under forms of energy than the scientific usage.
- (g) A force is a form of energy, gravity is a form of energy.
- (h) Energy is not conserved – rather it is used up in many devices such as appliances and cars i.e. no energy or less energy is given off in other forms.
- (i) Computers and televisions, use up much more energy than an electric kettle.
- (j) Energy sources (e.g. solar, hydro or coal) are not distinguished from types of energy (e.g. radiant, gravitational potential or chemical).
- (k) Transformations involving nuclear energy are different to other transformations in that only they involve mass being turned into energy.

2. Light/How we see

- (a) Light only travels a short distance from a candle/light bulb and then stops, usually before it gets to our eyes (this is less common in older students).
- (b) Light does not leave (bounce off) non-luminous objects except for very smooth (i.e. shiny) ones such as mirrors.
- (c) 'Sight' or light travels from our eye to objects we look at.
- (d) Light from a bright light travels further than light from a dim light.
- (e) Light travels further at night than during the day.
- (f) Owls, bats and cats can see in complete darkness, human also can see (not well) in complete darkness if we wait a while for our eyes to adjust.
- (g) Coloured filters (e.g. cellophane paper) add colour to white light.

3. Electricity

- (a) Electricity does not need a circuit to flow: only one wire is needed from the power source to the appliance.
- (b) The plastic insulation on wires holds the electricity inside the wire in a way analogous to water pipes and water. We need the plastic to keep the electricity in the wire as it goes around corners.
- (c) If the switch is on, then electric current is flowing in the terminals of a light socket from which the light bulb has been removed.
- (d) Electricity gets used up as it goes around a circuit: there is more electricity at the start of a circuit than near the end.
- (e) Positive current leaves one end of a battery and negative current leaves the other end, these clash in the light bulb. Nothing returns to the battery.
- (f) Batteries contain a store of electricity or electrons, there are no electrical particles in the wires before the switch is switched on, they flow out of the battery (or power point).

4. Floating and sinking

- (a) If something floats it must be completely on top of the water.
- (b) A fish just below the surface is not floating.
- (c) Weight matters: a heavier object, no matter what its size or shape, could not float as easily as a lighter object.
- (d) A larger, heavier object will not float as well as a smaller, lighter object made from the same material (e.g. a big block of wood and a smaller block of the same wood).
- (e) The amount of water matters: an object will float higher in a bigger container of water.
- (f) In order for an object to float, there must be a greater weight of water than the weight of the object (i.e. a 100 kg boat cannot float in 10 kg of water).

5. Heat

- (a) Heat is a kind of substance; things expand when heated to make room for the heat. Heat travels (like a fluid) through conductors.

- (b) Temperature is a measure of the amount of heat – if you mix two (equal) cups of water at 40°C the result will be at 80°C (or some intermediate temperature).
- (c) The temperature of two materials that have been in the same place for a long time (e.g. a bike left outside overnight) can vary (e.g. metals are cold but cloth is warm).
- (d) Blankets warm things – a wrapped up thermometer will warm up.

6. Gravity

- (a) Gravity is due to air pressure; it is a push from above; there is no gravity in a vacuum or on the moon.
- (b) Gravity is due to the earth's spin.
- (c) Gravity is weaker under water.
- (d) Gravity is greater on high mountains or tall buildings (it is easier to fall).
- (e) Gravity is noticeably less on high mountains or tall buildings and increases as we lose height (so this is why falling objects speed up).
- (f) Astronauts in space shuttle are beyond earth's gravity and so are weightless.

7. Force and Motion

- (a) A chair is not pushing up on a person sitting on it – it merely stops them from falling down. Similarly a car is not pushing back on a person pushing it i.e. reaction forces do not exist (or are not actual pushes or pulls).
- (b) There is a (large) forward force on a golf ball after it has left the tee, a football after it has been kicked etc. This forward force gradually decreases so the object slows, and stops when the forward force is all gone.
- (c) Friction is not a force, it is just something that slows things down.
- (d) Friction is only present when things are moving.

- (e) Friction gradually wears away/uses up the forward force on moving things.
- (f) Heavier objects will always fall faster than lighter objects.
- (g) If something is moving, then there must be a (net) force on it.
- (h) If an aircraft is climbing at a steady rate, then the upwards force (lift) must be greater than the downwards force (gravity).
- (i) The upwards force in an aircraft comes from the ailerons, the wing does not contribute an upwards force.
- (j) The faster an object is moving, the greater must be the net force on it.
- (k) Moving things are always moving in the direction of the (strongest) force on them.
- (l) When a car brakes suddenly, the occupants experience an equally sudden FORWARD force.
- (m) When moving around a corner, objects experience an OUTWARDS force (called a centrifugal force).

Broadly Biological Science

8. Living/non-living

- (a) Any of fire, the sun, clouds, rivers and even objects such as vacuum cleaners and cars (WHEN OPERATING) may be seen as living, i.e. children often have wider use of the term 'living' than its use in science.
- (b) Non living is the same as dead.
- (c) The particles in our body are alive.

9. Plants

- (a) Any of large trees, commercially cultivated vegetables and weeds may **not** be seen as plants; plants are often seen as small and medium sized things we buy in nurseries (i.e. unlike 'living' children's use of the term 'plant' is often more restricted than its use in science).

- (b) Plants obtain their energy from food they take in from the soil.
- (c) Rotting matter returns energy to the soil for plants to use.
- (d) Matter is created from the sun's energy when plants grow. A plant growing from a seed in a sealed container will cause the weight of the container plus contents to increase.
- (e) Plants take in all the substances they need to grow through their roots.
- (f) Plants take in water through their leaves.

10. Animals

- (a) Any or all of humans, birds, fish, insects, worms (and others) are not animals.
- (b) All animals can move independently from one place to another.
- (c) Animals are four footed and furry creatures plus some reptiles.
- (d) Animals are large, not very small and they dwell on the land (i.e. as with 'plant' children's use of the term 'animal' is typically much more restricted than its use in science).

11. Food/Digestion/Excretion

- (a) Energy (kilojoules) is/are a substance in foods in the same way as carbohydrate and protein are. If we eat too many kilojoules they turn into fat.
- (b) Our body actively selects the food it needs by absorption from the intestine; if we do not need (say) more protein then it will remain in the intestine and be excreted in our faeces.
- (c) We can only make fat from fatty foods.
- (d) Sugar and salt are harmful to, or are not useful to our bodies.
- (e) Food turns into energy in our body.
- (f) When we diet, we lose the weight as energy and/or sweat.

- (g) All or most of the food we eat, even low fibre food, emerges through the anus.
- (h) Urine, like faeces, is made up of the 'left over' liquids we could not use.

12. (Other) Human Physiology

- (a) Our systems operate in isolation from each other (e.g. the circulatory, respiratory and excretory systems are not connected to each other).
- (b) Muscles are not found all over the body, but only in some places such as arms and legs.
- (c) Intestines are found inside the stomach.
- (d) Blood leaves veins/arteries/capillaries in some parts of the body: the lungs, (and/or) fingertips, (and/or) muscles.
- (e) Blood vessels end in a dead end; the blood turns around and flows back along the same tubes (i.e. big blood vessels do divide into small ones, but these do not reconnect back into bigger vessels).

13. Genetics/Evolution

- (a) Genes are **only** found in the blood (it's in the blood) or only found in the brain or only found in the reproductive organs.
- (b) A person cannot carry genes for a characteristic (e.g. red hair) that they do not display.
- (c) Organisms build up immunity to outside agents (e.g. mosquitoes and DDT) which are passed on to their offspring.
- (d) Acquired changes (e.g. muscle development, permanent sun tans) can be passed on to offspring.
- (e) The genes for adaptations develop in response to an evolutionary pressure.
- (f) Genetic inheritance involves an averaging of the genes from both parents (e.g. dark skin and white skin leads to brown skin). So each of a child's characteristics is somewhere in between those of the parents.

Broadly Chemical Science

14. Air/gases

- (a) Air is weightless or has negative weight.
- (b) Helium has negative weight.
- (c) There is air in between air particles/molecules.
- (d) The dust and or germs in air are about the same size as air particles.
- (e) The particles in still air are not moving.
- (f) The only gas we breathe out is carbon dioxide.

15. Matter

- (a) Liquids (e.g. water in a syringe) can be compressed.
- (b) Gas means the gas(es) we use as fuels in gas stores, BBQs etc.
- (c) Matter is not conserved; it disappears or appears during processes such as dissolving, burning, evaporation, boiling, rotting, respiration, rusting, condensation, and growth of trees.
- (d) Matter is continuous, not particulate.
- (e) Energy and/or heat and/or sound are forms of matter.

16. Change of State/Water Cycle

- (a) When water boils or evaporates it goes straight to clouds (there is no water vapour in air).
- (b) When water in a saucer evaporates, the water has soaked into the saucer.
- (c) The (visible) steam from kettles rises, as visible steam, to form (visible) clouds ie there is no water vapour in clear air.
- (d) We sweat more on a humid day.

- (e) Rain falls when the clouds are too full of water and it drips out (or the cloud bursts open).
- (f) Coldness comes out through the walls of (say) a can taken from the refrigerator and turns into water.
- (g) The bubbles in boiling water are bubbles of air, or oxygen, or heat.
- (h) All liquids boil at 100°C; boiling water must be hotter than non-boiling, heated oil.
- (i) If you melt and refreeze cooking fat several times it will stay as a liquid (cooking oil).
- (j) A sample of liquid will become lighter if it turns into a gas (in say a sealed container).

17. Materials and Properties

- (a) Hardness is the same as or closely linked to strength (i.e. the stronger an object is the harder it is).
- (b) Metals (e.g. iron, copper) are harder than ceramics (e.g. glass, china).
- (c) Two component adhesives (e.g. Araldite) work in the same way as adhesives such as paper glue: by 'drying', hence each component will set if left long enough.

18. Particle Theory

- (a) The space between particles is not empty.
- (b) The (microscopic) particles have the SAME PROPERTIES as the (macroscopic) object they make up: ice particles melt, iron particles rust, all particles expand when heated, concrete particles are hard, cheese particles are soft etc.
- (c) Atoms are not conserved in many chemical reactions: they grow in the bark of trees, their numbers drop during processes such as combustion, decay and photosynthesis.
- (d) During chemical changes atoms change (e.g. iron atoms turn into rust atoms).

19. Dissolving

- (a) Dissolving is the same as melting.
- (b) The microscopic particles in (say) sugar disappear or become smaller when the sugar dissolves.
- (c) The dissolved substance (solute) in a solution is not taking up any space.
- (d) Only the taste and/or colour is left when something dissolves, not the substance itself.

20. Combustion

- (a) Smoke is a gas.
- (b) The fuel all turns into smoke.
- (c) The fuel turns into heat and smoke.
- (d) All substances become lighter when they burn. If fuel burns in a sealed container, there will be a drop in weight of the container plus contents.
- (e) Air is not actively involved in combustion.
- (f) Liquid (and solid) fuels burn while in the liquid (or solid) state – i.e. they do not turn into a gas first.
- (g) There are no particles in a flame.
- (h) The black (carbon) that forms when many substances (organic substances) burn (e.g. sausages on a gas BBQ) comes from the flame.

21. Acids

- (a) Acids corrode/dissolve a much wider range of substances than they do.
- (b) All acids are poisonous.
- (c) Acids are (inorganic) chemicals found in laboratories and car batteries (i.e. not in kitchens).

Broadly Earth and Space Science

22. Earth Science

- (a) Soil has always been present; if removed it could not reform even over eons.
- (b) Soil is made from bits of dead plants or animals.
- (c) A river valley is formed by earth movements, not by the river at the bottom of the valley.
- (d) Valleys (and mountains) have always been present.
- (e) The lava from volcanos comes from the centre of the earth.

23. Space Science

- (a) The sun goes around the earth.
- (b) The moon can never be seen during the day.
- (c) It is hotter during our summer, because the Southern Hemisphere is closer to the sun than the Northern Hemisphere.
- (d) During summer the earth is closer to the sun than it is during winter.
- (e) Gravity acts downwards in a direction below the South Pole (as it does on a globe in a classroom). An object dropped into a hole that went right through the earth would fall out the other side.