Alternative frameworks

And

Misconceptions in Primary Science

Two classes of children exploring forces with Lego Technic vehicles in the school hall.

A Discussion

By Gordon Guest
(with minor editorial changes by Keith Ross)

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Misconceptions in Primary Science.

Two definitions taken from the Collins Concise English Dictionary 1988.

1. **Misconceive. To fail to understand.**

2. **Misconception false or mistaken view, opinion or attitude.**

When children hold views that differ from conventional scientific explanations or classifications they are often referred to as “misconceptions, alternative conceptions, alternative frameworks or children’s ideas.

While the origins of children’s beliefs are uncertain, they are thought to have been formed as the result of previous experiences. For instance, some children describe the evaporation of water from a puddle as the water disappearing (Russell and Watt 1990). Some are influenced by folklore, that eating carrots helps you see at night (WW2 British propaganda), or the media; e.g. space ships explode with sound. The ideas have coherence; they make sense and seem to be useful in explaining children’s own experiences of everyday phenomena. Furthermore since ideas of this kind are intuitive and fruitful for children they are resistant to change.

There is agreement that children are not passive recipients of knowledge but that conceptual development involves the active construction of new knowledge, a process that produces a change in ideas. There is agreement that the ideas children bring with them to science lessons have an impact on learning outcomes.

Some Historical developments in science teaching.

In the last 15 to 20 years there has been a change in the way we think about primary children’s learning in science. The emphasis from the 1900’s to the 1950’s was on the learning of facts and repeating “classical scientific experiments “ used to illustrate a particular point. A style that is still common in some secondary schools despite numerous projects for change.

The emphasis from the 1960’s to the 1980’s and later, was on the process skills of science, such as observing, inferring and predicting. The view that process was more important than content has changed as research indicates the complexity of learning.

Science now recognises that when children, or adults, learn science conceptual understanding is a fundamental component of that learning. Many basic science concepts and understandings help us to make sense of our world and they are relevant to learners of all ages.

Thinking and working scientifically requires in part a focus on understanding science ideas in order to make sense of our world, but also an appreciation of the way science derives those ideas and the forms of evidence it accrues to substantiate them.

Research around the world indicated that at the end of secondary school large numbers of students still held many ideas, or conceptions, which were not in accord with the way that scientists understood our world.

These scientifically incorrect conceptions have been given numerous names, such as, misconceptions, preconceptions, naïve conceptions, alternative conceptions and alternative frameworks. The UK literature tends to use ‘scientific misconceptions’ whereas literature from elsewhere (e.g. Australia, USA) uses the term ‘alternative conceptions’.

Recent Ideas in science.

It is now suggested (Feasey 1997) that there are **two key elements** to the teaching and learning of science.

1. **There is a conceptual scientific background.** That is the key scientific ideas, the knowledge about science and the essential ability to apply concepts.

2. **The understanding of evidence**. How and why scientists collect evidence and an understanding of and ability to challenge the reliability and validity of evidence in order to decide on its believability.

These views are clearly developed in the Science National Curriculum (1999) with a programme of study developing Scientific Enquiry and three programmes of study developing knowledge. It is also evident in the Foundation Stage (2000) through the goals of scientific exploration.

Because science is often in conflict with our common sense view of looking at the world, it sometimes doesn’t make sense. (Cross and Peet 1997). The problem for the teacher is that explanations for phenomena and the concepts being developed derive from a vocabulary rooted in everyday experience. It is from this vocabulary that we reason about scientific ideas.

For example, when added to warm tea, sugar goes into solution. the sugar is the solute and the warm tea the solvent. Here we have a familiar phenomenon described precisely with an unfamiliar vocabulary. For the learner, scientific ideas must develop or evolve, demanding interpretation in such a way that some words take on a different meaning.

Schemes, models of learning and information processing.

A model introduced by cognitive scientists fits well with what we now know of the interaction between the child’s different ideas and the manner in which these ideas evolve with teaching. This model argues that information is stored in the memory in various forms and that everything we say or do depends on the elements or groups of elements of this stored information. People use this stored information to inform learning make decisions and react to situations.

This information processing of stored information is called schemes. A scheme may concern an individual's knowledge about a specific phenomenon (for example the sensation of cold when handling ice cubes) or a more complex reasoning structure (for example considering how to use variables in fair testing such as the brighter the bulb, the deeper the shadow will be).

Thus the term scheme denotes the diverse things that are stored and interrelated in memory. These schemes may also influence the way a person may behave and interact with the environment, and in turn may be influenced by feedback from the environment.

So reception children will describe large ice balloons as soft because they feel smooth. Their association of the word smooth is that it is something you do to a cat or dog. And while they see the ice melt and turn to water they do not link the water and the ice – they describe them as separate discreet properties – whereas older children (KS2) will make these connections.

Similarly Y2 children will talk about animals breathing, eating and moving but may not give those attributes to plants.

The term misconceptions (alternative conceptions or frameworks) indicate that a learner, child or adult has not understood the scientific idea.

Science ideas are evolutionary.

> *"Research shows that there is a remarkable similarity in the ideas children use to explain the world around them." (Harlen 2000 p40)*

There is clear research evidence that understanding in science is a gradual process and that at certain ages children seem to have similar misconceptions regardless of where in the world they live. In making sense of ideas in science, the learner is involved in an evolutionary process requiring constant refinement, redefinition and interpretation. The evolution of ideas is therefore a core element of teaching and learning in science at all levels and should be actively encouraged in the development of understanding.

Recent research in brain development also indicates that between 0-6 years the brain becomes wired, it develops the neurological connections needed to make sense of experiences. (Greenfield S. 2000) There are thus apparent connections between the brains physical maturation and the ability for it to process information to aid learning. Education in a broader sense argues that learning should be for understanding, **so attention should be paid to children's capability to process information.**

Understanding is a continuous process that goes on through life. It is impossible to say that anyone achieves complete understanding. Think of the different understanding a 6 year old, a 16 year old and a 26 year old research chemist would have for the concept of "dissolving".

For the 6 year old it might mean a solid becoming no longer visible when put in warm tea. The 16 year old may have linked several phenomena and envisage it as a process that depends on the nature of the two substances brought together. The 26 year old Chemist will link it to the molecular structure of these substances.

The difficulty with scientific concepts is that they are often counter-intuitive and the complex understanding needs to be built up slowly layer upon layer.

Giving children facts that do not link into their own experiences and thinking can deter them from asking questions since they find that they cannot understand the answers.

But scientific concepts are often complex to understand!

The Earth spins on its axis at approximately 1000 miles an hour at the equator, which is 25,000 miles in circumference. Yet at the poles the earth is virtually motionless because the circumference is smaller and it therefore travels less distance. (Asimov 1987 Ch4)

So how is it I am standing still yet moving at 1000 miles an hour? What ideas can children bring to make sense of these phenomena?

Light travels at 297,000,000 metres per second.

How do you interpret such information?
What understanding do you individually make of this?

A Language framework for learning science.

One step in helping children make sense of science ideas is to help them acquire the correct language.

1. *Acquisition of Language. This is the first stage of the process. Words are acquired through discourse in social interaction and are given meaning from the experiences we associate with them. For example the word weight acquires meaning through experiences of the particular property of an object which is different from its other properties such as shape, colour or size.*

2. *Translation. The second part of the process is one of translation. This is context related. The word weight acquires further meaning through association with heavy and light. The meaning of the word is translated into understanding through comparison and contrast. Weight is commonly associated with size and the distinction between weight and size often requires refinement and reinforcement in different contexts. This process of translation from a range of everyday common sense experiences, although important, is insufficient in itself in developing scientific understanding of the world.*

3. *Interpretation. Many scientific terms such as weight can be interpreted in different ways. There is everyday meaning, which is a sense of heaviness, frequently associated with bulk and there is the scientific meaning which is that weight is a force. If understanding of the word is to evolve from the everyday to the scientific then it is necessary to provide experiences that draw attention to the new or extended meaning of the word. As with translation, the opportunity to compare and contrast is integral to the process. This might be achieved for example by drawing attention to the effect that the force of weight has on structures or floating objects.*
   (Cross and Peet 1997 p39)

Each stage of scientific language development involves comparison and contrast of the new with existing experience in order for ideas to evolve.

Developing scientific concepts.

Children's ability to process information, their thinking ability, develops slowly with experience and interaction and the information processing capability of a particular child will set limits on the complexity of concepts that the child can cope with. We have operations in the workings of our minds, or ways of thinking, which enable us to construct knowledge. This development is not just a matter of becoming faster or more full of knowledge: there are qualitative changes in the way that children process new information as they develop cognitively.

Stages of cognitive development were identified by Piaget and labelled as;

- **Sensori- motor**
- **Pre-operational**
- **Concrete and**
- **Formal operational**

The sense children make of science depends on their ability to process information and this is both a function of what they know already, and of their thinking skills. The development of their thinking skills may, in broad terms, be linked with brain maturity and cognitive development. This maturation period is similar to the stages identified by Piaget.

A Table indicating how scientific understanding may increase with children's age.

Stage.	The Earth in Space	Electricity and current	Solutions
1 R/Y1	Earth is flat like a disk, an absolute idea of down.	Only one wire is needed for a circuit.	Salt disappears water gets no heavier
"2A Y2?Y3	People live all over the surface of the earth; drawings show them all the same way up.	Two wires, the current comes down both from cell to bulb. Clashing currents model.	Salt mixes with water, which gets heavier, but no change in volume. Salt is still there but may not be recoverable.
2B Y5/6	People on surface of the Earth feet all towards the centre.	Current circulates it gets less as it goes around.	The salt in water process is reversible salt and water can be recovered.
3 some Y6 some Y7/8	Idea of down relative to the centre of the Earth.	Current remains constant, but there is a transfer of energy	Explanation in terms of particles and salt and water mixing

Chart taken from; p162,

Monk M and Dillon J. 1995 Learning to Teach Science. Activities for Student Teachers and Mentors. Falmer press London.

Looking at Children's ideas in science.

PoS. 2 Life processes and Living Things.

How do we know it's alive?

Children have a restricted meaning of the word plant. Some consider a tree is a plant when it is little but not when it's big – **it's a tree!** Others think that plants are cultivated so weeds such as dandelions are not plants. Some children will say that carrots and cabbage are vegetables rather than plants.

Some children consider only large animals found in zoos, farms or at home as pets can be animals – a close link between mammal and animal, though people are seldom considered to be animals by younger children. Other animals were grouped by various criteria, number of legs, wings etc.

Young children may have very different ideas about what is living. They tend to over emphasise movement as a characteristic of living things and some may suggest that clouds and fire are alive because they move.

Others suggest trees flap their branches (because teacher says plants move) to lose their leaves. (Not a property of the invisible wind)

Y5 and Y6 children usually understand the 7 characteristics of being alive. Reception and Y1 children may only manage 3 or 4 characteristics

E.g.;-

- breathing
- eating
- drinking
- moving
- some may consider going to the toilet as part of being alive

Questions to consider!

- **do plants go to the toilet?**
- **are there animals that do not urinate?**

Older children often have the idea that plants "breathe out" oxygen during the day and carbon dioxide at night.

Children are confusing two quite different processes: photosynthesis, which operates only in the light, and respiration, which goes on all the time.

Children don't distinguish germination of seeds from their subsequent growth. Different conditions are required for each – during germination only respiration takes place, but once the green shoots appear photosynthesis can start.

If asked where the material of the plant comes from, many children and adults will suggest that it comes only from the soil. Many do not realise that most of the plant material is produced through photosynthesis. That a large tree trunk is composed of carbon converted from the CO_2 in the air; i.e. air becomes a solid substance.

Children often think that seeds contain miniature plants waiting to grow. Human babies, snail babies are miniature versions of the adult. The connection between one form of baby and a plant is a misconception.

Sensing and moving.

Children use their senses, touch, smell, taste, sight and hearing to inform them about their surroundings. So living things that do not have all the senses e.g. plants and taste may not be alive.

The fact that many animals do not have the same senses as humans supports the view of many children that humans are a distinct category and not an animal.

Only a minority of children seem to be aware of the circulation of the blood or the functions of the heart and blood.

Many children ignore the function of internal organs that are not measurable. Lungs, heart stomach bones have a clear function that can be physically felt. Kidneys, Liver, intestine have functions that cannot be felt.

Children often think that food and drink travel through the body separately. They will draw different tubes through the neck.

The idea that 90% of our food is fuel and 10% is for growth is often lost in a quest to understand ‘healthy’ foods and ‘balanced diets’. Most people say that ‘food is energy’, rather than realising that it provides us with fuel. The fuel is then respired, using oxygen, to produce carbon dioxide and water with energy becoming available during the reaction.

Other living Things.

Children may say; “A sheep grows a warm coat so it can live in cold places. A polar bear grows a white coat to live in the snow a brown bear has a brown coat to live in the mountains.”

They assume the animal can choose this attribute. Sheep cannot somehow decide to equip themselves for an environment. Animals adapt to their environment – a warm coat and a white coat helps the animal survive in that habitat.

Food Chains.

Children often understand food chains in relation to the food they eat, such as:

Hen eats corn

Hen lays eggs

Eggs

Boiled/fried eggs

Children are often confused about the direction of the arrows and fail to mention the Sun as the ultimate source of energy. KS2 children get mixed up about consumers and producers and primary consumers at the top of a food chain.

People often say, confusingly, that energy is passed along food chains, whereas it is biomass (biological material). At each level most of the biomass is used by the animal as fuel, and some is used to build the cells of the animal.

Energy is stored when the sunlight splits water and carbon dioxide during photosynthesis. As long as the biomass and oxygen are kept apart, energy is stored. When a living thing needs energy it respires some of the biomass by joining it with oxygen, releasing water and carbon dioxide again. Most people muddle up energy and matter and do not see that food has to be respired (with oxygen) to transfer energy

Younger children in the Foundation Stage and Key Stage 1, particularly those living in urban areas, may believe that nothing happens without a human cause. They may think that hills were made by people. That wild animals in zoos behave in a particular way because of people. They may focus on the negative aspects of human influence, such as litter and vandalism, while nature is seen as attractive.

Children are more likely to notice differences than similarities. When asked to explain differences, young children in particular may simply say: God made them that way.

Children have difficulty with the scientific grouping of living things, even into plants and animals. They tend to use these terms when describing particular plants or animals: flowers are plants but grass is not, a cat is an animal but a person is not.

They need to practice sorting and grouping animals in many different ways, land, air sea, big, small, many legs few legs scales or fur etc.

(Scientists group living things into – Bacteria (+ viruses), Protista, Fungi, Plants, Animals – with backbones – without backbones)

PoS 3 Materials and their properties.

Materials.

The ideas children have about the use of materials for various purposes are circular. We use paper for writing on because paper is good for writing on.

Children use their everyday experience of rust on cars and gates to conclude that rust is already there under the surface so there is no need for an explanation.

> For example an 8 year old wrote, ***"Screws are made of metal. Rust comes out of metal."*** (Harlen 2000 A. p44)

Children use the word material to mean fabric. They tend to classify objects according to their uses rather than their properties. An important distinction children need to make early on is the difference between an object (with its properties) and the material(s) from which it is made (with their properties)

Composite or mixtures of materials cause difficulty i.e., brass, and manufactured and man made cause problems. E.g. a table is natural wood but man made. A car is natural metal but manufactured.

Solids, Liquids and gases.

Young children often do not realise that water can exist as ice and change back to water. They may think that ice formed on a pond in winter has been added the way that we add ice to drinks.

Foundation Stage children will hold ice cubes (ice balloons) and see the water dripping from the ice but not link the water and the ice. The pool of water and the ice cube are two distinct properties.

Children often use the word solid to mean heavy, not flexible, or in one big piece. It is then difficult for them to classify substances such as flour, or salt as a solid.

When cooking children talk about the cake mixture, the bread mixture but later on find it hard to use the scientific term of mixture accurately.

(A mixture is – two or more distinct chemical substances and the components retain their individual chemical properties. Mixtures can be separated by physical means.

In a compound a substance formed by the combination of elements in fixed proportions. The formation of a compound involves a chemical reaction. Compounds unlike mixtures can not be separated by physical means)

Mixing and separating.

Children often describe dissolving as disappearing and say that the salt or sugar has disappeared. They often confuse the terms melting and dissolving.

(Melting = 1 substance changing from solid to liquid. Dissolving = 1 substance mixing into a liquid substance to form a solution)

Young children are not always aware that materials exist in different forms (states) or how materials can change from one to another. They may not have noticed that some changes are reversible while others are irreversible.

Rocks and soil.

Children assume that rocks are rocks. They do not discriminate. They also call hard large objects, concrete, tar, clay etc rocks. At KS2 they need assistance in simple rock classification. Children find the idea that soil is formed from very small bits of rock conceptually difficult.

Weather.

Children have their own theories about why the weather changes. For instance “The same weather goes around the world and we get it when it is our turn.

(A misconception often linked with explaining night and day where the earth is shown spinning around and the light shines on part of the earth only. Weather is interpreted in the same way)

They also have their own ideas about rain. Water is sucked up from the sea into clouds. When the clouds are full the water is let out as rain. When asked why clouds would do this a common answer is God told them to. (Think about the cloud people in James and the Giant peach how stories can convey a believable understanding). “***The cloud is like a magnet!”***

Young children do not see the need to explain why water dries up, - ***“it just goes by itself”*** (Harlen 2000 A. p45)

PoS 4. Physical processes

Forces and Movement.

Children apply their own ideas to force.

- **Children identify force with living things – there is some intention involved.**
- **Objects in constant motion need a constant force to keep them moving in the same way (confusion with momentum).**
- **An object that is not moving has no forces acting on it**
- **A moving body has a force acting on it in the direction of motion (confusion with momentum).**

Children think of forces in terms of movement, not staying still. Children are likely to believe that if something is not moving there are no forces acting on it. (Think of a person trying to push a car with the handbrake on. The car does not move so to children no force is evident. Yet scientifically we know there are several forces at work)

Children find the force arrows in diagrams difficult and think they do not make sense. This is because scientists use force arrows from the centre of gravity not the top or bottom of an object. They are also confused with movement and momentum

Children think that heavy objects sink and light ones float. There is a grain of truth here, because, in everyday language, ‘heavy’ can mean ‘dense’, and light can mean low density – as in “Polystyrene is light, stone is heavy”. The research suggests there is a direct correlation with age in understanding properties of floating.; that there are significant differences between the ages of 5 and 8 and 8 and 11. (Harlen 2000 A. p49)

Children also suggest that things float better in a large volume of water than in a small volume. They may also deny that floating is taking place. Foundation Stage children observing ice balloons floating in water did not think the ice balloons floated. Similar confusion can exist when describing helium balloons floating in air. Often no connection is made between the idea of floating in water and floating in air. Children need to place material half way down in water to test them – if they move upwards they ‘float’ and if they move downwards they ‘sink’

Energy.

(This is not a requirement in the National Curriculum but sometimes it is important to raise the issue of energy.)

Children confuse ideas of energy with those of force. When looking at mechanical energy through wind up toys they may believe energy is wound up. So when looking at energy through photosynthesis they imagine some wind up property inside a plant – tiny springs inside leaves.

The main confusion with energy is that we talk of ‘using’ energy or “energy is needed to do this job”. In this sense we are talking of high grade useful energy. During ‘use’ the energy scatters and becomes useless waste heat. So although energy is not used it becomes progressively less and less useful, meaning we need a constant input of high grade energy to keep our systems going. Nature and climate use the daily input of energy from the sun to keep going.

Electricity.

Children often believe that a single wire connection from a bulb to a battery will work, probably because they think that appliances in their homes work with only one wire. The plastic casing at home contains two or three wires but children do not see these, they therefore reason there is only one wire. Children from KS1. KS2 and KS3 persist with the idea that a circuit only needs one wire to light a bulb even when they can make a circuit work with two wires.

Many children imagine electricity to be a sort of fuel that flows into an electrical appliance. In this sense they are appreciating **electrical energy** that is ‘generated’ in a power station (or from a cell) and is transferred to light, movement etc at the appliance. The question then arises – why do we need a return wire? Children need to distinguish between **electrical energy** that is transferred from cell to bulb and **electrical current** that goes round and round picking up energy and delivering it.

Some children think that electricity comes from thunder and lightening, or from the sky. Many do not accept static electricity e.g. from rubbing a balloon on a jumper as a form of electricity.

Magnets.

Children often think that magnets stick to objects because they have magical properties or some kind of glue.

Varnished wooden blocks when wet will stick together. Children will describe this as magnetic. Different types, sizes and shapes of magnets will confuse. Magnetic strength will often be attributed to the “biggest” magnet.

This is a good time to get children to appreciate that there are many sorts of metal but only iron & steel (and cobalt, nickel and some alloys) are magnetic. Distinguishing aluminium and iron cans for recycling is a useful activity

Sounds.

Children often have their own ideas about sound travelling, such as “tunes are very small and they can get through gaps in doors”. Early years children find the idea of sound vibrations confusing. Some children think there is something in the ear that actively catches the sound, (similar to the BFG catching dreams or the numbskulls in the Beano)

There is also a distinction in many children's minds (particularly KS2) between sound and vibration. Where the sound can be actively seen as vibrating this is acknowledged e.g. a ruler, a string telephone. Where it cannot be seen it is given a vague attribute – a tune, a noise.

Light sources and vision.

Children consider seeing as an active process. We see a book because light comes out of our eyes (like superman) and travels to the book. Older KS2 children have difficulty interpreting the light arrows in diagrams. Some suggest that opening and closing the eye is similar to switching on a light in a room. When the eye is open light pours out from it.

This usually causes a few problems in the Y6 SAT's.

Children are very confused about shadows and reflections, as this example shows,

"I think a shadow is a reflection from the Sun. Sometimes when you look in a pond you see a reflection. When you go somewhere where it can reflect you see your shadow."

The position of the sun in the summer sky and winter sky gives rise to further confusions about shadow length.

Children often do not relate the colours they see to the materials the objects are made of. E.g. plants reflect green light so the natural (British) landscape looks green.

The Earth in Space.

It is not self evident that the Earth is a planet orbiting the sun. We notice the sun's apparent movement across the sky each day and talk about the sun rising, coming up, going down, setting going behind clouds, all of which imply that it is the Sun rather than the Earth that is moving.

Children may tell their teacher that the Earth is round, but their responses to questions often show that they really consider it to be flat.

Children sometimes say that there is no gravity on the moon, or that things will float away on the moon because there is no air to hold them down.

Space films will show great explosions in space as if they are scientifically correct. Although Teachers explain that this is scientifically wrong, the images from Star Wars are stronger than a teacher's explanation.

Young children may say that night happens because we need to sleep, because the Sun swaps with the moon, or because the sun has gone to Australia.

Children often think that we have summer when the earth is close to the sun rather than due to the tilt of the axis. If this were so all the earth would have summer at the same time: point out to them that when we have summer Australia has winter.

Young children often think the moon is a series of cut out shapes stuck in the sky and when we see the moon in the daytime it is God playing tricks on us.

Summary.

Many of the children's ideas and misconceptions make sense. They are logical interpretations of the information the children currently have. Indeed these misconceptions make more sense than the scientific view, which is counter, intuitive. The scientific view frequently makes use of ideas based on things that are not observable by the children, such as water vapour, unseen forces, vibrations in air etc. Often science requires children to link together several unseen abstract concepts.

Take, for example, the moon. We see the moon in the sky at night and sometimes in the daytime. To make sense of the sun, moon, night and day we have to accept that

- **the earth spins around every 24 hours**
- **The earth is always half lit up by the sun, and half is in darkness**
- **the moon has an orbit around the earth so it is sometimes in the day-time sky**
- **we see the moon because of the sun's reflection from the surface of the moon**
- **the moon is always half lit up by the sun (just like the earth), with half in darkness**
- **from the earth we sometimes see the side of the the moon that is lit up (full moon) sometimes we see half the lit side and the other half is dark (half moon) and sometimes we 'see' the unlit side (new moon)**

Scientific understanding requires ever more complex acceptance and understanding of invisible forces that most people do not appreciate in their normal lives.

The scientific explanation to many people is just as fanciful as the Maori legend of how the moon was formed, or the stories of Greek Gods.

It is not surprising tha, compared to the complexity of science, children's intuitive ideas have several shortcomings.

Harlen (2000 A. p54) suggests several reasons for this, which could include one or more of the following:

- **Children's experiences are necessarily limited and therefore the evidence is partial. –** so they may well consider rust to be within metals if they have only paid attention to it when it appears under paint or flaking chrome.

- **Children pay attention to what they perceive through their senses rather than the logic, which may suggest a different interpretation** – so if the sun appears to move around and follow them then they think it, does move this way.

- **Younger children (Early Years) particularly focus on one feature as cause for a particular effect rather than the possibility of several** - for example, the factors in the conditions needed for living things to grow healthily.

- **Although it may satisfy them, the reasoning they use may not stand comparison with scientific reasoning.** For example, if they made genuine predictions based on their ideas, these ideas would be disproved. But instead they may predict what they know to fit the idea.

- **They may use words (vocabulary) without a grasp of their meaning** – we have seen that this can happen with floating, vibration (sound) and evaporation, but many more examples could be cited.

- **They may hold on to earlier ideas even though contrary evidence is available because they have no access to an alternative view that makes sense to them. In such cases they may adjust their ideas to fit new evidence rather than give it up,** as in the idea that light turns the eye on.

Terry Russell director of the SPACE project argues that children also need a lot of time to assimilate new ideas, and that mental learning, information processing, is best achieved by frequent practical hands on work to embed the concept.

Implications for teaching.

- Provide children of all ages with lots of hands-on practical work to help embed the concept in a mental schema, but make sure they predict what they think will happen.
- If an idea is derived from a narrow range of evidence then provide more evidence
- If testing a prediction based on an idea could help challenge the child's existing idea then help the child to make that prediction and consider the challenge. This should assist children in fair testing and using process skills.
- If the pupils' use of words is suspect then ask the child to give examples and non examples of what they understand the words to mean. Develop a scientific dictionary, word bank etc.
- If children have a locally correct idea about a phenomenon in one situation but do not recognise that the same explanation holds in different situations they need to be helped by the teacher to make links between the situations. This may mean repeating experiments, for example evaporation through clothes on a line, water in a dish a jar and puddles on the playground.

Each strategy helps the teacher support the child in extending their conceptual understanding.

Where do I go to Research the issue of Misconceptions?.

The term misconceptions means the same as the term alternative frameworks.

Originally children were thought to misunderstand the science hence the term misconception. However more recent research suggests the children have an alternative framework and the reasoning they use is quite logical.

For example

Children exploring wooden blocks in water. When lifted out they discovered the two wooden blocks stuck to each other. They knew nothing about surface tension of water and related this to the only other experience they had magnetism. The blocks are magnetic! (See Harlen B p34 – 36 for details of this account).

They might also mix up ideas about cotton wool, wool and cotton. Never having seen a cotton plant they see cotton wool as white and fluffy, that matches their experience of woollen clothes and pictures of sheep. So cotton wool comes from sheep. (See Harlen 2003 p144 –146)

Children have very clear ideas about how light travels and how it is seen. When we talk about the processes of life we discuss, breathing, moving, eating, all of these require a physical action. So they naturally attribute action to seeing and imagine beams of light coming out of our eyes. Such ideas are being reinforced by superman films. So they believe seeing is an active and not a passive process. (See Hollins and Whitby 2001 p164)

Gravity is another problematic area. An Invisible force is pulling us all down towards the centre of the Earth and keeps us from falling off the earth as it spins at thousands of miles an hour and people in Australia are not upside down but the right way up! They will interpret these explanations in relation to their experiences. (See Ross et al 2004 p36 –49)

A clear example is the child who claimed that all orange objects float. When questioned they admitted they wore orange armbands in the swimming pool, when these were on they floated and when they were off they sank. Further practical work, blowing up different coloured balloons and floating them on water made the child realise it was not the colour but the air inside the armbands that kept them afloat. The difficulty they had was trying to explain something for which they did not have the range of vocabulary and experiences needed. As they gained these they could make their explanation more explicit and meaningful.

That is they could change their alternative framework.

Keith Skamp (1998) in nearly every chapter discusses the teaching implications and how you change student's ideas. Throughout his book he does NOT use the term misconception he talks about Alternative Conceptions the summary he provides on p3 and 4 is well worth copying.

The book by Keith Ross et al (2004) Teaching Secondary Science explores misconceptions and children's naïve ideas in great detail and would be a good place to start your background research.

For your assignment you need to ELICIT children's ideas in the classroom and match these ideas to scientific misconceptions. The Literature will give you guidance on;

Elicitation strategies and children's scientific ideas and misconceptions.

Misconceptions in Science Bibliography.

ASIMOV I. 1984 *Asimov's New Guide to Science* 3rd Edition St Ives Penguin.

ATKINSON S. and FLEER M. (1995) *Science with Reason* London Hodder and Stoughton

BENTLY D and WATTS M (1992) *Communicating in School Science.* (p56-92 communicating in group work) London Falmer Press.

De BOO M. (1999) ***Enquiring Children, Challenging Teaching Early Years Science*****.** Buckingham. OUP

De BOO M (2000) ***Science 3 to 6. Laying the Foundations in the Early Years***. Hatfield ASE

COLLINS EDUCATIONAL (1997) *Nuffield Primary Science. Understanding Science Ideas. A Guide for Primary Teachers.* London. Collins Educational

CROSS A. and PEET G. (1997) *Teaching Science in the Primary School. Book one. A practical source book of teaching strategies*. Exeter Northcott House

DRIVER R. GUESNE E. and TIBERGHEIN A. (1985) *Children's Ideas in Science*. Milton Keynes OUP

GLAUERET E. (1995) Tracking Significant Achievement in Primary Science London Hodder & Stoughton (p1 – 41)

GREENFIELD S. (2000) *The Human Brain* 2nd Edition Guernsey. Guernsey Press.

GOLDSWORTHY A. FEASEY R and BALL S. (1997) *Making Sense of primary Science Investigations.* Hatfield ASE

HARLEN W. (1976) *Match and Mismatch Raising Questions* London Oliver and Boyd

HARLEN W. (1976) *Match and Mismatch Finding Answers* London Oliver and Boyd

HARLEN W. (1985) *Taking the Plunge* London Heinemann (p70 – 92 Children's own concepts)

HARLEN w., & Jelly S., (1989) Developing Science in the Primary Classroom. London Oliver & Boyd. (p36 – 52)

HARLEN W. (1996) The Teaching of Science in Primary Classrooms London David Fulton. (p8 – 43)

HARLEN W. (2000 A.) *Teaching Learning and Assessing Science 5 – 12.* London. Paul Chapman

HARLEN W. (2000 B.) *The Teaching of Science in Primary Schools.* 3rd Edition. London. David Fulton

HARLEN W, Macro C., Reed K., Schilling M., (2003) *Making Progress in Primary Science*. London Routledge Falmer

HARNQVIST K. & Burgen A. Eds. (1997) Growing up with Science. Developing an Early Understanding of Science. Bristol Jessica Kingsly. (p41 – 78)

HOLLINS M & Whitby (2001 second edition) Progression in Primary Science KS1 and KS2 London David Fulton (p1 – 12)

MACRO C. (2003) ***Science in the Early Years. The Foundation Stage***. (Ch 5) in HARLEN W, Macro C., Reed K., Schilling M., (2003) *Making Progress in Primary Science*. London Routledge Falmer

MONK M and DILLON J. (1995) *Learning to Teach Science. Activities for Student Teachers and Mentors*. London. Falmer press

OLLERENSHAW C. & RITCHIE R. (1997) Primary Science making it work. London David Fulton. (p37 – 104 Elicitation & Restructuring)

OGBORN J., Kress G., Martins I & McGillicuddy K. (1996) *Explaining Science in the Classroom*. London OUP (Reworking knowledge p25 - 44)

Open University (1985) Block 2 The Science Book EHP531 *Primary Science Why and How*. London OU. (p25 – 44) an excellent summary.
+
RATCLIFFE. M. Ed (1998) *ASE Guide to Secondary Science Education.* Hatfield. ASE

SHERRINGTON R. Ed. (1998) *ASE Guide to Primary Education.* Hatfield ASE

SKAMP K. (1999) *Teaching Primary Science Constructively.* Sydney Harcourt Brace

ROSS K., Lakin L., Callaghan P. (2004) *Teaching Secondary Science* Second Edition. London David Fulton

RUSSELL T. (1989 to 1998) *Project reports from SPACE*. Liverpool. Liverpool University Press.

Apart from the books listed above there are many journals, which discuss science education. Key Journals to become familiar with are those produced by the ASE, Association for Science Education. These are

- Primary Science Review
- Education in Science
- Science Teacher Education
- Secondary Science Review

All of these journals will have interesting articles in them.

Key authors on children's conceptual understanding are: -

- Jonathon Osborne
- Rosalind Driver
- Keith Ross
- Wynne Harlen
- Ron Ritchie

Nuffield Primary Science. Science Processes and Concept Exploration. (1998) Understanding Science Ideas. A Guide for Primary Teachers. Collins Educational London.

Note.
(The Nuffield Primary Science scheme is a science scheme for use with pupils in KS1 and KS2. It has a wide range of pupil books and teacher books. The particular strength of the scheme is that it was developed from the SPACE research project (which lasted 10 years) at Liverpool University. Each unit of the Nuffield Science scheme comes with a comprehensive teachers book. These teacher books are essential reading to understand children's ideas in the classroom and the misconceptions they might come up with.)

Nuffield Primary Science.
Teachers Guide for KS1 and KS2 on the following topics.

The Earth in Space
Electricity and Magnetism
Forces and Movements
Light

Living Processes
Living things in their environment
Materials
Rocks, soil and weather
Sound and Music
Using Energy
The Variety of Life

The **Primary Science Processes and Concept Exploration** (SPACE) project. Edited by Terry Russell, Linda McGuigan, Dorothy Watt. Liverpool University Press Liverpool. (Research project ran from 1989 to 1999). Titles include

Evaporation and Condensation
Growth
Light
Sound
Electricity
Materials
Forces
Energy
Genetics and Evolution
Earth in Space
Processes of Life
Variety of Life