Are scientific concepts of life involved?

Science and Sustainability in the Natural World: Why this is important?

This might appear to be a strange title, after all doesn't all science take place 'in the natural world?' Where else could it be taking place? When we examine science more closely we might start to wonder; it is often divorced from the natural world, leading to scientific outcomes which cause more harm than good. So what does science in the natural world look like?

The Real World Learning Network has been exploring the teaching of science outside. One of the key issues we are interested in finding out is the sort of scientific understanding we need to help develop thinking and action for sustainability.

We started by exploring what we meant by 'understanding', coming quickly to the conclusion that it is not just all about scientific reasoning, the rational aspect of science. Although important, reason needs to sit alongside our emotions, values and humanity; this is where the true understanding emerges.

Principles of Ecology

Networks: All living things in an ecosystem are interconnected through networks of relationship.
Nested Systems: Nature is made up of systems that are nested within systems. Each individual system is an integrated whole and — at the same time — part of larger systems.
Cycles: Members of an ecological community depend on the exchange of resources in continual cycles. Cycles within an ecosystem intersect with larger regional and global cycles.
Flows: Each organism needs a continual flow of energy to stay alive. The constant flow of energy from the sun to Earth sustains life and drives most ecological cycles.
Development: All life changes over time. Individuals develop and learn, species adapt and evolve, and organisms in ecosystems co-evolve.
Dynamic Balance
Ecological communities act as feedback loops, so that the community maintains a relatively steady state that also has continual fluctuations. This dynamic balance provides resiliency in the face of ecosystem change.

(Source: Centre for Ecoliteracy)

Through exploring the science that we need to understand in order to support a sustainable planet, we have used existing research on Planetary Boundaries by the Stockholm Environment Institute to frame our work. The Planetary Boundaries show the resilience of nine environmental areas, and measure whether they are currently within the planet's capacity to sustain them. For example, biodiversity is listed as beyond the safe operating capacity, while global freshwater use remains within the safe operating capacity (see www.stockholmresilience.org for more).

Planetary Boundaries offer a useful approach to deciding what science needs to be understood to support a sustainable planet. But herein lies the danger of just using a reductionist based science; we try to understand the details of each boundary rather than the overall patterns and processes which link them together. And we are led down the path of individual scientific solutions to global issues, rather than approaches which address social and economic issues as well as environmental ones.

The Real World Learning Network has done much to explore the teaching of Planetary Boundaries. However, for learning to be effective it must include our emotive responses to the natural world; we need to understand the whole system that is operating, not just each individual piece of the jigsaw.

By going back to nature and closely observing, we see that nature operates through a set of inter-operating principles. Fritjof Capra calls these Living Systems, based on the principles of ecology (see boxed text). The Real World Learning Network has synthesised these principles down to four that can be easily understood and integrated into outdoor science learning.

Cycles: nature operates within cycles, nothing is created nor destroyed. Cycles are processes that can be repeated continuously without degrading the ability of other processes to continue. Diurnal patterns of sunrise and sunset, and seasonal cycles of spring through to winter take place and are celebrated. Nitrogen, phosphate, carbon and oxygen cycle through processes such as transpiration, decomposition, weathering and photosynthesis.

Change: nothing stays the same, there is constant evolution as biodiversity adapts and variations emerge; energy transfers and changes as it flows from sun to leaf to insect; molecules of carbon, hydrogen and oxygen constantly come together and break apart as they form the structures of all materials.

Stability: nature is in dynamic balance; ecosystems do not evolve towards monopolies with only a few dominant species; all things are interdependent, based on the causes and conditions which created them. All systems have feedback loops, acting to maintain the system in a relatively stable state.

Energy flow: energy originating from the sun cascades through systems changing from light to chemical energy via photosynthesis and into mechanical energy through digesting plants to create carbohydrates which power animal life.

These principles are not just natural principles which are useful as approaches to outdoor learning; they act as metaphors and frames for how we develop our communities and economies. A stable community, for example, is one which responds to feedback, realises its interdependence both internally and with the world around it, and develops its own social assets to be resilient in an ever changing world. It can be seen that these system principles are derived from nature and can be studied scientifically, but when applied to communities they become powerful metaphors for a creative, positive and sustainable future.

Scientific Materialism

A belief that everything is made of matter and that everything that happens is the result of the physical interactions and properties of that matter. It supports a scientific understanding based on reductionism; that we can understand a process or entity by reducing it to its parts and in this way understand the whole.

When we take onboard the study of holistic science we understand the processes and patterns of relationships that enable nature to sustain life. We also understand how scientific materialism has ignored these basic principles and led humanity towards ecological, and ultimately self-destruction. Recognising these fundamental causes of many of our global problems offers the hope for change. This is why a real world learning approach to science in and from the natural world is so important; for nature not only opens us up to our place in the world it also teaches us the principles for sustainable living. Working with holistic science, means a shifting of perspective from looking at parts to considering whole systems, it is multidisciplinary focusing on relationships, mapping and processes. It is important to consider how we understand knowledge and the limits of this knowledge.

Parts & Wholes

Living systems are made up of parts, which are integrated together. The parts have properties which we find out about by studying the parts. Whole systems have properties, which are properties of the whole, which none of the parts have individually. We can find out about whole systems only by the whole system. This means we need to look closely at individual parts of the living system and stand back and look at the whole system and its properties, otherwise we only get some of the picture and some of the understanding.

Multidisciplinary

The world is made up of parts integrated into systems. Parts such as a cell or leaves, parts such as humans or families. There are social systems as well as ecosystems. All systems share common properties and principles, so to understand these life supporting systems we need to take a multidisciplinary approach. It is not just about Biology, our study needs to include economics, sociology or any branch of human learning that helps us understand.

Key Question examples for a Woodland Invertebrate Study:

Stability: What might happen if a tree fell down, how would that change the population numbers of a particular invertebrate? What would happen to the food web or the whole woodland ecosystem, in a storm?

Energy Flow: What are the food chains in a woodland? What are the food webs? What's the trophic structure like in woodland? What would happen if the top predators were poisoned and died in large numbers?

Change: Which species are adapted to different places? Why? What are the places like? What would happen if the places changed?

Cycles: From the definition of cycles I came up with the question of "How do the seasonal cycles impact on the life cycle of an invertebrate or groups of invertebrates?"

Objects & Relationships

Systems 'nest' within larger systems. For example cells are parts of tissues, tissues are parts of organs, living systems are parts of social systems. At each level each system is an integrated whole, having some properties (emergent properties) that can only be seen at that level (see parts and wholes). Each of these parts is an integrated whole, with parts of its own, as well as being a smaller part of something bigger itself. So, each part is linked to other parts in a web built of relationships to other parts like itself, as well as relationships to simpler parts and more complex parts of the whole system. Studying the parts without the relationships, doesn't give us the whole picture. We need to study the relationships between the parts, as well as the parts.

Measuring & Mapping

In studying parts, we measure and count the objects, but what about the relationships. To study these we need to map them. We start to look for the patterns of the relationships, we look for things that repeat themselves. We need to look at how we define an object, where the most useful boundary of the object is so we can measure and count it, but more importantly we need to define the object boundary so that we can look at the network of relationships that the object might have. Relationships are about quality not quantity, and this is how we must look to study them.

Structures to Processes

Every system's structure is derived from its processes. Living things and systems are more than their shape, more than the static configuration of parts. There is a flow of matter through a living system, while its form stays the same. We need to study the processes that underlie this form, as well as the structure and form itself.

Understanding the processes of knowing

The systems view of reality as a network of relationships, means that to study and understand this effectivity and wholly, different scientists may divide up the system into different parts and produce different understandings and knowledge about these parts. These different methods of questioning become inherent in the understanding of the system. We cannot understand something without looking at how we decide to question, observe or study it. This means our methods of questioning, our understanding of the process of knowing, our epistemic approach is an important aspects of our knowledge.

Certainty & Approximation

'In the epistemic approach to science, nature is seen as an interconnected web of relationships, in which the identification of specific patterns as objects depends on the human observer and the process of knowing'. If this is true, we can only ever understand limited and approximate concepts and theories of reality, it would be impossible to know everything in a Cartesian way.