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Inter-relationships

The essence statement of the draft revised NZ science curriculum states that in their study of the living world students are expected to gain an understanding of "living things and their interactions with the environment." It is not difficult for students to grasp the basic idea that living things depend on each other and the physical environment for their survival (Interdependence of life). This awareness, though, needs to be supported by knowledge about the specific needs of a variety of organisms and their relationships with other living and non-living things in the environment. (The American Association for the Advancement of Science).

Progressions in learning about inter-relationships

Studies of interactions between things within an environment should start with relationships that can be directly observed. Students should become familiar with a variety of ecosystems, starting with those that are local. Once students are familiar with a large range of examples of interdependency of organisms they can move to a more generalised view of the types of interactions that take place within the environment. Even when they do have this more general understanding, it is still important to go back to specific examples when a new type of ecosystem is introduced. Lack of specific knowledge can lead to faulty generalisations.

Moving from specific and concrete to general and abstract

The importance of developing "big ideas" within specific contexts is also backed up by Boyes and Stanisstreet (1996). They researched children's ideas about a number of global environmental issues such as global warming and the hole in the ozone layer. They found that although children are aware of many of these issues, their understanding of them is muddled. They argue that, in order to develop an understanding of these difficult and complex issues, children need to be presented with specific examples rather than generalised terms. For example rather than talking about pollution, it may be more useful to talk about specific pollutants and the processes by which they pollute.

Boyes and Stanisstreet suggest that we need to be careful about the sort of vocabulary we use when talking about the environment and also to ensure that we explore our students' thinking and alternative ideas about environmental issues.

Systems level thinking

Planet Earth consists of various systems (e.g., rock cycle, water cycle, food webs, carbon cycle) which all involve the transitions of matter and energy from one form to another. In the context of science, then, it is important that students learn to think at a "systems" level if they are to gain a real appreciation of how the environment works and make informed decisions about the application and implications of science in every day life. Students need to learn to think in terms of the "big picture" and about how things are related to each other rather than in terms of discrete, detailed facts. We call this systems level thinking. It involves knowing about the individual parts of a system, the role each part plays and how these parts interact to function as a whole.

Progressions in "systems level" thinking

The main goal for young students in ultimately developing systems level thinking should be to get them to attend to the various aspects of a system (American Association for the Advancement of Science). In order to develop the ability to think about a system, children must first be able to identify the components and the processes within the system. They can begin to attend to what affects what, in simple terms, and talk about what might happen to a particular system if some parts are missing or broken. This stage should not be rushed. Descriptions of parts and their interaction are more important than just calling everything "a system". As their thinking becomes more sophisticated students develop ideas about how every part of a system relates to the system as a whole, and about the processes involved:

- For a system to work well all parts must be working well.
- The output from one part of the system can become the input for another part.
- Feedback from different parts can help control what goes on in the system as a whole.
- Any system is usually related to other systems.

Assaraf and Orion (2005) identified **8 characteristics of systems level thinking**. In some recent work with children learning about a waterway ecosystem, NZCER researchers identified 3 different stages of development in **thinking about systems**.

Thinking about systems

A sophisticated understanding of how living things interact with the environment includes a sense of the complex and changing nature of relationships.

When analysing students’ responses about relationships within a waterway ecosystem we judged students to be at an early stage in their development in thinking about systems if they did not identify a relationship or made a very general comment about a relationship without any specific detail.

Those students who either identified an appropriate direct relationship between two components (e.g., the fisherman ate the fish) or gave specific information about parts of the system that are linked without explaining the relationship were considered to be at the next level. (The detailed information about parts is essential if students are to make valid generalisations at a systems level).

Students who identified the effects of one relationship on another (e.g., The fisherman ate the fish so the birds that eat fish went hungry) were considered to be developing some sense of the complexity and balance in the ecosystem. As these ideas develop further students can identify more relationships and impacts from changes that are further away in terms of either time or distance.

In our discussions we became aware that an understanding of scale is important for increasingly complex understandings of how systems work. At an early stage for instance a student thought spilling cordial into the river at a picnic could pollute the waterway and make the water change colour.

In looking at the students' responses about waterways we identified both direct and indirect human effects on the ecosystem. Direct effects included fishing, picnicking, kayaking, swimming, walking a dog, just being there, drinking water, playing, directing polluting, littering and scaring, attacking or killing animals.

In the table below quotes from students about the impact of fishing have been used to try and illustrate different stages of development in thinking about systems.

May identify many parts of a system but no specific relationships	We saw eels, whitebait, and trout in the stream.
Appropriate direct relationships **Identifies parts of the system that are linked without explaining the relationship**	The fisherman catches the fish and eats it. (direct) The person is fishing for fish with his fishing rod. (parts)
Multiple relationships that impact on each other	The humans can eat the fish so the kingfishers etc won't have much to eat. People fishing makes the algae grow more because fish aren't eating it.

Indirect effects of humans on the waterways ecosystem included pollution, chopping down trees and destroying habitat, introducing animals/ plants, introducing diseases, changing the course of waterways, damming, hydro power, building, waste pipes/storm water drains, erosion and impacts of farming including positive measures such as building fences to keep stock away from waterways.

In the table below quotes from students about the impact of pollution have been used to try and illustrate different stages of development in thinking about systems.

May identify many parts of a system but no specific relationships	Humans who pollute the waterway could contaminate it. Smoke from houses pollutes the water.
Appropriate direct relationships **Identifies parts of the system that are linked without explaining the relationship**	Gases and acids would make the waterway toxic and kill all the plants, fish, and anything near the bank. (direct) Storm water drains flow into rivers. (parts)
Multiple relationships that impact on each other	People can upset relationships by polluting the water which kills the fish and the birds can't feed on them. Companies by water drop oil waste into waterways therefore killing the trout and other fish. The reeds will overgrow, algae will spread and this will cause blockage of drains. (attempts at multiple effects – dynamic) – misconceptions about feeding.

References

Assaraf, O., & Orion, N. (2005). Development of system thinking skills in the context of Earth system education. *Journal of Research in Science Teaching, 42*(5), 518-560.

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