*Biology> Big idea BOE: Organisms and their environments > Topic BOE1: Interdependence of organisms*

|  |
| --- |
| **Key concept (age 11-14)** |
| **BOE1.2: Interdependence within ecosystems** |

**What’s the big idea?**

A big idea in biology is that all organisms, including humans, depend on, interact with and affect the environments in which they live and other organisms that live there.

**How does this key concept develop understanding of the big idea?**

This key concept helps to develop the big idea by exploring ways in which the organisms within an ecosystem are interdependent.

The conceptual progression starts by checking understanding of the idea that an ecosystem is made up of a community of organisms interacting with the environment in which they live. It then supports the development of ideas about feeding relationships, pollination, seed dispersal and decomposition as examples of interdependence, in order to enable understanding of how changes in the size of a population can affect other populations throughout the ecosystem.

**Using the progression toolkit to support student learning**

Use diagnostic questions to identify quickly where your students are in their conceptual progression. Then decide how to best focus and sequence your teaching. Use further diagnostic questions and response activities to move student understanding forwards.

**Progression toolkit: Interdependence within ecosystems**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Learning focus** | An ecosystem is made up of interdependent populations of organisms  interacting with each other and the environment in which they live. | | | | |
|  |  |  |  |  |  |
| **As students’ conceptual understanding progresses they can:** | **C o n c e p t u a l p r o g r e s s I o n** | | | | |
| Recall that an ecosystem is made up of a community of organisms interacting with the environment in which they live. | Recall that the community of organisms in an ecosystem depends on producers to make food. | Recognise that some plants depend upon animals to pollinate them and disperse their seeds. | Recognise that all living organisms depend upon decomposers that can break down dead organic matter. | Apply understanding of ways in which organisms are interdependent to predict effects of a change in the size of a population. |
|  |  |  |  |  |  |
| **Diagnostic questions** | Ecosystem words | Phytoplankton | Pollen and seeds | What happens next? | The bees are disappearing |
| Producers and consumers |
|  |  |  |  |  |  |
| **Response**  **activities** | What makes up an ecosystem? | Food chain Jenga! |  | No more microorganisms | |
|  | Ecosystem connections role play |

|  |  |  |  |
| --- | --- | --- | --- |
| Key: | | | |
| **P** | Prior understanding from earlier stages of learning | **B** | Bridge to later stages of learning |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Ecosystem words** | **Phytoplankton** | **Producers and consumers** | **Pollen and seeds** | **What happens next?** |
|  |  |  |  |  |
| Linking ideas | Two-tier multiple choice | Confidence grid | Focussed cloze | Simple multiple choice |
| **The bees are disappearing** | **What makes up an ecosystem?** | **Food chain Jenga!** | **No more microorganisms** | **Ecosystem connections role play** |
|  |  |  |  |  |
| Two-tier multiple choice | Discussion | Modelling, discussion | Talking heads, discussion | Role play |

**What’s the science story?**

Organisms of the same type living in the same place make up a population. Populations of organisms living in the same place interact to make up a community. An ecosystem is made up of a biological community and the physical environment in which the community lives and upon which it depends.

Producers make their own food, and all consumers depend upon producers for food. Feeding relationships, which can be depicted using food chains and food webs, are one aspect of interdependence within ecosystems. Additional aspects of interdependence include that some producers depend upon consumers to pollinate them and to disperse their seeds, and that all organisms depend upon decomposers to break down dead organic matter. A change in the size of one population will affect the sizes of other populations in the same community.

**What does the research say?**

*Ecosystems and interdependence*

All organisms live as members of populations in a community within an ecosystem; and all organisms compete with and are dependent upon each other for survival. A number of authors have noted the importance of learning about the interdependence (or “connectedness”) of organisms within ecosystems. As Allen (2014) has pointed out, “Anyone who is not able to fully appreciate the far-reaching impacts of changes to a single population may trivialize a media report about an endangered species, only believing that species alone is under threat, when the likelihood is that many members of an ecosystem will be adversely affected”. Many researchers have recognised the difficulties that school children have in reaching this kind of understanding, which seems to be due to misunderstandings of key ideas including how the biotic and abiotic components of ecosystems are organised, that they interact, that they are interdependent/connected, that ecosystems exist in a state of balance, and that this balance can be perturbed by changes over time (e.g. Grotzer and Bell Basca, 2003; Sander, Jelemenska and Kattmann, 2006).

There is a common misunderstanding that humans are separate from ecosystems; Odum (1977) argued that “we are abysmally ignorant of the ecosystems of which we are dependent parts”. This could create or reinforce dangerous misunderstandings such as that our actions do not affects ecosystems, that changes in environments and non-human populations of organisms will not affect us, and that we could somehow survive without the organisms upon which we depend.

Some classic studies investigated how children’s thinking about the relationships between themselves, other organisms and ecosystems develops from age 5 to age 16 (e.g. Leach et al., 1992). Children aged 5-7 are most likely to demonstrate egocentric (self-centred) thinking, focussed on humans and perhaps extended to organisms that are kept and cared for directly by humans (e.g. domesticated or captive animals and plants), and to only think about individual organisms rather than populations. Children aged 7-11 are more likely to demonstrate anthropocentric (human-centred) thinking, including awareness of wild organisms (usually as individuals rather than populations) perhaps with the incorrect idea that these need to be fed, watered or cared for by humans, or sometimes with incorrect teleological thinking that other organisms exist in order to provide food or other ecosystem services to humans . Older children are more likely to think about populations of organisms (rather than individual organisms) living in the wild, though will often struggle to describe their interrelationships or interdependence without resorting to incorrect teleological explanations or simple statements such as “birds live in trees” or “foxes eat rabbits” (Driver et al., 1994; Munson, 1994). There is evidence that incorrect teleological explanations of interdependence – namely that some organisms exist specifically for the benefit of others (e.g. to feed them) – persist in students up to tertiary level (Brumby, 1982).

There is some evidence that even when students are aware of feeding relationships between organisms, they fail to appreciate that these are an example of the interdependence of organisms (Driver et al., 1994). In a study of students aged from 13 up to undergraduate level, most biology students knew that animals could not exist without plants, but only one quarter of these students could explain that this is because animals cannot make their own food and some thought that carnivores could exist seemingly indefinitely without plants by feeding on their prey (Eisen and Stavy, 1988).

Barker and Slingsby (2011) emphasise that developing understanding of key ecological concepts is best achieved in the context of real ecosystems that students can visit, observe and explore; as they put it, “What we are trying to do is make them leap out of the textbooks”. Additionally, a number of authors have suggested using role play (e.g. Ford and Smith, 1994) and games (e.g. Biffi et al., 2016; Hartweg et al., 2017) to increase engagement and help develop students’ understanding of interdependence within ecosystems.

*Beyond feeding relationships*

It is important for students to appreciate that the interdependence of organisms within an ecosystem arises from more than just feeding relationships (Driver et al., 1994; Allen, 2014).

All of the organisms in a food chain can depend upon animals that pollinate plants and disperse their seeds, and human food security is critically dependent upon animals that perform these services for food crops (Díaz et al., 2006). Researchers have found that the misunderstanding that plants do not reproduce sexually (because they do not ‘have sex’) is common in teenagers (Okeke and Wood-Robinson, 1980; Hampshire Education Authority, 1986); this misunderstanding could prevent students from appreciating the important role of pollinators in ecosystems. Pollinator populations are in decline, at least in part due to human activities that result in habitat loss, bioaccumulation of substances such as insecticides, and climate change (Potts et al., 2010), and learning about the important roles of pollinators in school can help to increase students’ engagement with biodiversity loss and conservation (Schönfelder and Bogner, 2017).

In addition, all living organisms depend upon decomposers that can break down dead organic matter and make essential elements available for reuse. Research has found that school children generally do not appreciate the important roles of microorganisms in decomposition and the recycling of carbon, nitrogen and other elements, with many associating microorganisms only with disease and associating decay only with rotting food (Brinkman and Boschhuizen, 1989; Leach et al., 1992). In one study in Isreal, almost one third of teenagers said they would eliminate all microorganisms from Earth if possible (Barenholz and Tamir, 1987).

Research in the UK, USA, Portugal and Sweden has suggested that students’ ideas about what happens to dead organic matter generally follow a progression from age 5-6, as follows (Sequeira and Freitas, 1986; Smith and Anderson, 1986; Helden, 1992; Leach et al., 1992):

|  |  |  |  |
| --- | --- | --- | --- |
| **Age (years)** | **Thinking on what happens to dead organic matter** | **Thinking on the products of decomposition** | **Category of thinking about conservation** |
| 5 | No ideas. | There are no products, or products not considered. | Non-conservation |
|  | It simply disappears. |
| It breaks down over time by undefined ‘natural processes’. |
| It breaks down (or ‘rots’) of its own accord, and birds/rodents/insects/’bugs’ eat it. | Enriches/fertilises the soil/ground. | Partial conservation |
| Unspecified ‘microorganisms’ cause it to break down. | ‘Forms soil’ (and thus the Earth is continually getting bigger). |
| It is decomposed by bacteria and fungi. | Produces soil minerals. | Conservation |
| 16 | Decomposers use it as food. | Produces soil minerals, carbon dioxide and water. |

*Everyday and scientific usage of ecological terms*

Students at age 11 are likely to be more familiar with the everyday, rather than the ecological, use of terms such as ‘population’, ‘community’ and ‘environment’ (Driver et al., 1994). In one study, a quarter of children in a sample of secondary school students thought that a ‘community’ could only be formed by people living together, and another quarter could not distinguish between ‘population’ and ‘community’ (Adeniyi, 1985).

**References**

Adeniyi, E. O. (1985). Misconceptions of selected ecological concepts held by some Nigerian students. *Journal of Biological Education,* 19(4)**,** 311-316.

Allen, M. (2014). *Misconceptions in Primary Science, 2nd* ednBerkshire, UK: Open University Press.

Barenholz, H. and Tamir, P. (1987). The design, implementation and evaluation of a microbiology course with special reference to misconceptions and concept maps. In Novak, J. D. (ed.) *Proceedings of the 2nd International Seminar: Misconceptions and Educational Strategies in Science and Mathematics, 26-29 July.* Ithaca, N.Y.: Cornell University.

Barker, S. and Slingsby, D. (2011). Ecology. In Reiss, M. (ed.) *ASE Science Practice: Teaching Secondary Biology.* 2nd ed. London, UK: Hodder Education.

Biffi, D., et al. (2016). Developing an educational tool to model food chains. *Electronic Journal of Science Education,* 20(1)**,** 40-53.

Brinkman, F. and Boschhuizen, R. (1989). Preinstructional ideas in biology: A survey in relation with different research methods on concepts of health and energy. In Voorbach, M. T. & Prick, K. G. M. (eds.) *Teacher Education 5: Research and Developments on Teacher Education in the Netherlands.* London, UK: Bloomsbury Paperbacks.

Brumby, M. N. (1982). Students' perceptions of the concept of life. *Science Education,* 66(4)**,** 613-622.

Driver, R., et al. (1994). *Making Sense of Secondary Science: Research into Children's Ideas,* London, UK: Routledge.

Díaz, S., et al. (2006). Biodiversity loss threatens human well-being. *PLoS Biology,* 4(8)**,** e277.

Eisen, Y. and Stavy, R. (1988). Students' understanding of photosynthesis. *The American Biology Teacher,* 50(4)**,** 208-212.

Ford, B. and Smith, B. M. (1994). Food webs and environmental disturbance: what's the connection? *American Biology Teacher,* 56**,** 247-49.

Grotzer, T. and Bell Basca, B. (2003). How does grasping the underlying causual structures of ecosystems impact students' understanding? *Journal of Biological Education,* 38(1)**,** 16-29.

Hampshire Education Authority (1986). Children's preconceptions in biology. Secondary Science Curriculum Review in Hampshire.

Hartweg, B., et al. (2017). Peruvian food chain Jenga: learning ecosystems with an interactive model. *School Science and Mathematics,* 117(6)**,** 229-238.

Helden, G. (1992). Pupils' understanding of ecological processes. Kristianstad University College, Sweden: Learning in Science and Mathematics Group Working Paper.

Leach, J., et al. (1992). Progression in conceptual understanding of ecological concepts by pupils aged 5-16. University of Leeds, UK: Centre for Studies in Science and Mathematics Education.

Munson, B. H. (1994). Ecological misconceptions. *Journal of Environmental Education,* 25**,** 30-34.

Odum, E. P. (1977). The emergence of ecology as a new integrative discipline. *Science,* 195**,** 1289-1293.

Okeke, E. A. C. and Wood-Robinson, C. (1980). A study of Nigerian pupils' understanding of selected biological concepts. *Journal of Biological Education,* 14(4)**,** 329-338.

Potts, S. G., et al. (2010). Global pollinator declines: trends, impacts and drivers. *Trends in Ecology and Evolution,* 25(6)**,** 345-353.

Sander, E., Jelemenska, P. and Kattmann, U. (2006). Towards a better understanding of ecology. *Journal of Biological Education,* 40(3)**,** 119-123.

Schönfelder, M. L. and Bogner, F. X. (2017). Two ways of acquiring environmental knowledge: by encountering living animals at a beehive and by observing bees via digital tools. *International Journal of Science Education,* 39(6)**,** 723-741.

Sequeira, M. F. and Freitas, M. (1986). Death and decomposition of living organisms: children's alternative frameworks. *11th Conference of the Association for Teacher Education in Europe.*

Smith, E. L. and Anderson, C. W. (1986). Alternative student conceptions of matter cycling in ecosystems. Paper presented to National Association of Research in Science Teaching.