Integration of Earth System concepts into a teaching program

The grid below illustrates how the concepts in Topic1: Earth System can be integrated into the teaching program at appropriate places within the other three topics. This illustration provides contexts for the teaching of the Earth System concepts.

**Topic 1: Earth System**

* 1. The four Earth spheres are the geosphere, atmosphere, hydrosphere, and biosphere.

1.1.1 Investigate the components of each of the four spheres.

1.1.2 Identify visible and ‘hidden’ components and processes of spheres.

1.1.3 Identify interactions between components of spheres.

1.1.4 Describe dynamic relations within and between spheres.

1.1.5 Organise components and processes into a web of interactions.

* 1. A change in any one sphere can impact others at a range of temporal and spatial scales.

1.2.1 Explain how changes in spheres can be caused by natural or human-induced factors.

1.2.2 Describe that changes within a sphere and between spheres can occur over a variety of time-scales.

1.2.3 Identify patterns and changes over a variety of time-scales.

1.2.4 Discuss how a change in the Earth’s spheres can influence conditions at a range of spatial scales from local to global.

* 1. Explain that changes in spheres may have cyclic or unpredictable patterns.

1.3.1 Examine changes in interactions between Earth spheres that have occurred in the past.

* 1. Predict future changes within and between Earth systems in a given area.

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| **Topic 4 Science Understandings** | **Topic 1 Science Understandings** |
| 1.1.1 | 1.1.2 | 1.1.3 | 1.1.4 | 1.1.5 | 1.2.1 | 1.2.2 | 1.2.3 | 1.2.4 | 1.3.1 |  1.4 |
| 4.1 Natural processes in the Earth’s atmosphere affect climate change over geological time |   |   |   |   |   |   |   |   |   |   |   |
| Discuss the evolution of the Earth’s atmosphere |   |   |   |   |   |   |   |   |   |   |   |
| Explain how the composition of the Earth’s atmosphere changes over time |   |   |   |   |   |   |   |   |   |   |   |
| Discuss the greenhouse effect |   |   |   |   |   |   |   |   |   |   |   |
| Explain how the lifespans of greenhouse gases and their ability to absorb infrared radiation contribute to their warming potentials |   |   |   |   |   |   |   |   |   |   |   |
| Discuss how solar energy is absorbed, re-emitted, and reflected by atmospheric gases and the Earth’s surface, including the albedo effect |   |   |   |   |   |   |   |   |   |   |   |
| 4.2 Natural processes outside of the Earth’s atmosphere affect climate change over geological time |  |  |  |  |  |  |  |  |  |  |  |
| Explain how astronomical cycles affect natural climate variability |  |  |  |  |  |  |  |  |  |  |  |
| Explain how variations in solar energy due to sunspot activity can contribute to natural climate change |  |  |  |  |  |  |  |  |  |  |  |
| 4.3 Natural processes within the Earth affect climate change over geological time |  |  |  |  |  |  |  |  |  |  |  |
| Explain how the plate-tectonic supercycle has contributed to global climatic changes throughout the Earth’s history |  |  |  |  |  |  |  |  |  |  |  |
| 4.4 Oceans absorb large amounts of solar radiation |  |  |  |  |  |  |  |  |  |  |  |
| Explain the effect of water’s large specific heat capacity on changes in ocean temperature |  |  |  |  |  |  |  |  |  |  |  |
| 4.5 Changes in oceanic circulation may impact on weather systems |  |  |  |  |  |  |  |  |  |  |  |
| Explain the difference between surface and deep-water ocean currents |  |  |  |  |  |  |  |  |  |  |  |
| Explain the relationship between the world’s wind belts and the world’s surface ocean currents |  |  |  |  |  |  |  |  |  |  |  |
| Explain the relationship between the thermohaline circulation and deep-water ocean currents |  |  |  |  |  |  |  |  |  |  |  |
| 4.6 Anthropogenic activities affect climate conditions |  |  |  |  |  |  |  |  |  |  |  |
| Explain the enhanced greenhouse effect |  |  |  |  |  |  |  |  |  |  |  |
| Describe anthropogenic activities that are changing the levels of greenhouse gases |  |  |  |  |  |  |  |  |  |  |  |
| Compare how local, national, and global policies can affect the levels of these gases |  |  |  |  |  |  |  |  |  |  |  |
| 4.7 Explain how carbon is stored in Earth’s systems over a variety of time-scales |  |  |  |  |  |  |  |  |  |  |  |
| Discuss the carbon cycle |  |  |  |  |  |  |  |  |  |  |  |
| 4.8 Climate change affects Earth systems |  |  |  |  |  |  |  |  |  |  |  |
| Discuss the effects of climate change on the Earth’s spheres |  |  |  |  |  |  |  |  |  |  |  |
| 4.9 Geological, prehistorical, historical, and contemporary records provide evidence that climate change has affected different regions and species differently over time |  |  |  |  |  |  |  |  |  |  |  |
| Investigate how contemporary levels of CO2 and temperature are monitored, and provide evidence of contemporary climate change |  |  |  |  |  |  |  |  |  |  |  |
| Explore how climate proxies are used to provide evidence of climate change |  |  |  |  |  |  |  |  |  |  |  |
| 4.10 Models for predicting climate change are based on past climate data and are continually changing |  |  |  |  |  |  |  |  |  |  |  |
| Explain how general circulation models can be used to predict future climate change |  |  |  |  |  |  |  |  |  |  |  |
| **Topic 2 Science Understandings** | Topic 1 Science Understandings |
| 1.1.1 | 1.1.2 | 1.1.3 | 1.1.4 | 1.1.5 | 1.2.1 | 1.2.2 | 1.2.3 | 1.2.4 | 1.3.1 |  1.4.1 |
| 2.1 People use the geological resources of the Earth to help satisfy their needs and wants |  |  |  |  |  |  |  |  |  |  |  |
| Compare the use of geological resources in various lifestyles |  |  |  |  |  |  |  |  |  |  |  |
| Discuss, using examples from a variety of cultures, ways in which geological resources are used |  |  |  |  |  |  |  |  |  |  |  |
| 2.2 Non-renewable mineral and energy resources are formed in various ways over geological time-scales, so are not readily replenished |  |  |  |  |  |  |  |  |  |  |  |
| Discuss the sustainability of reserves of fossil fuels, and metallic and non-metallic resources |  |  |  |  |  |  |  |  |  |  |  |
| 2.3 The formation and exploration of non-renewable metallic mineral resources is related to their geological setting |  |  |  |  |  |  |  |  |  |  |  |
| Explain how metallic ores may be concentrated by gravity-settling and hydrothermal processes |  |  |  |  |  |  |  |  |  |  |  |
| Explain how the processes of weathering, erosion, and deposition may concentrate metallic ores |  |  |  |  |  |  |  |  |  |  |  |
| Explain how the formation of iron ore (banded iron formations) occurred in an anaerobic environment |  |  |  |  |  |  |  |  |  |  |  |
| Identify metallic ores, using their physical and chemical properties |  |  |  |  |  |  |  |  |  |  |  |
| Discuss techniques for finding mineral resources, using magnetic and electromagnetic surveys, geochemical sampling, and drilling |  |  |  |  |  |  |  |  |  |  |  |
| Discuss how the presence of a resource can affect the surrounding physical and chemical environment |  |  |  |  |  |  |  |  |  |  |  |
| 2.4 The depth, extent, and location of mineral resources determine the method of extraction |  |  |  |  |  |  |  |  |  |  |  |
| Describe the essential features of underground, open-cut, and in-situ leaching methods of extraction of mineral resources |  |  |  |  |  |  |  |  |  |  |  |
| Explain how the size, shape, and depth of a mineral deposit influence the choice of extraction method |  |  |  |  |  |  |  |  |  |  |  |
| 2.5 The formation and exploration of non-renewable energy resources, including fossil fuels and unconventional gas, is related to their geological setting |  |  |  |  |  |  |  |  |  |  |  |
| Explain the processes by which coal is formed |  |  |  |  |  |  |  |  |  |  |  |
| Describe the processes by which petroleum and coal-seam gas are formed and are trapped |  |  |  |  |  |  |  |  |  |  |  |

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| **Content** | 1.1 | 1.2 | 1.3 | 1.4 |
| 1.1.1 | 1.1.2 | 1.1.3 | 1.1.4 | 1.1.5 | 1.2.1 | 1.2.2 | 1.2.3 | 1.2.4 | 1.3.1 |  1.4.1 |
| Describe structures within which petroleum may be trapped |  |  |  |  |  |  |  |  |  |  |  |
| Explain how seismic and gravity surveys are used in petroleum exploration |  |  |  |  |  |  |  |  |  |  |  |
| 2.6 The depth, extent, and location of energy resources determine the method of extraction |  |  |  |  |  |  |  |  |  |  |  |
| Explain how petroleum, shale oil, coal, and coal-seam gas are extracted from the Earth in different locations |  |  |  |  |  |  |  |  |  |  |  |
| 2.7 The extraction and use of mineral and energy resources influences interactions between the abiotic and biotic components of ecosystems, including hydrologic systems |  |  |  |  |  |  |  |  |  |  |  |
| Describe potential environmental impacts that can be associated with the extraction, use, and processing of mineral and energy resources |  |  |  |  |  |  |  |  |  |  |  |
| **Topic 3 Science Understandings** | Topic 1 Science Understandings |
| 1.1.1 | 1.1.2 | 1.1.3 | 1.1.4 | 1.1.5 | 1.2.1 | 1.2.2 | 1.2.3 | 1.2.4 | 1.3.1 | 1.4.1 |
| 3.1 Renewable resources include some that are available regularly and others that are replenished at time scales from years to millennia |  |  |  |  |  |  |  |  |  |  |  |
| Discuss the need for, and limitations of, renewable sources of energy, including biofuels, solar, wind, and geothermal energy |  |  |  |  |  |  |  |  |  |  |  |
| Determine whether a renewable resource is either diminished or sustained over time, given the abundance of the resource and how readily it can be replenished |  |  |  |  |  |  |  |  |  |  |  |
| Investigate how the timescale required to replenish a large groundwater system, such as the Great Artesian Basin, is influenced by the rate of depletion of the system |  |  |  |  |  |  |  |  |  |  |  |
| Discuss the sustainability of soil and water at local, regional, and global scales |  |  |  |  |  |  |  |  |  |  |  |
| 3.2 The availability and quality of fresh water can be influenced by human activities, and natural processes at local and regional scales |  |  |  |  |  |  |  |  |  |  |  |
| Discuss how storm water run-off in urban areas may be recycled for community use so that it is not wasted and does not pollute waterways |  |  |  |  |  |  |  |  |  |  |  |
| Explain how over extraction of groundwater from near-coastal aquifers may cause inflow of sea water |  |  |  |  |  |  |  |  |  |  |  |
| Explain how pollution of groundwater can result from a variety of rural, urban, and industrial activities |  |  |  |  |  |  |  |  |  |  |  |
| 3.3 The effective use of energy resources is constrained by factors including waste disposal, and the efficiency of available technologies to collect, store, and transfer the energy |  |  |  |  |  |  |  |  |  |  |  |
| Compare the advantages and disadvantages of using renewable and non-renewable energy resources |  |  |  |  |  |  |  |  |  |  |  |