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The International Earth Science Olympiad (IESO): Goals, objectives and syllabus

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A. Introduction: goals and objectives

The Earth Sciences discipline has undergone a significant change since the mid-70's of the previous century. This change manifests itself in the shift from reductionism approach in which each domain of the Earth Sciences (Geology, Hydrology, Atmosphere) was considered an independent discipline to a holistic approach that emphasizes the connection among the Earth systems. During the 1980's these domains have been united into one discipline – the Earth Sciences. In the 1990's a new discipline evolved as part of the Earth Sciences, namely, Environmental Geology or Earth Systems.

This vast discipline has a variety of environmental aspects which are included in the Earth Sciences discipline. For example:

The mutual influence between natural systems (Human involvement excluded) like the influence of chemical erosion of volcanic rocks on the carbon dioxide balance and as a result, changes in the climate.

The influence of human intervention on nature, like changes in the composition of the atmosphere which cause air pollution, pollution of the water in the oceans and in fresh water sources. Overuse of natural resources, intervention in coastal processes, removal of waste and its influence on the environment, or the increasing of floods.

The ability to forecast disastrous natural phenomena like floods, storms, earth quakes, volcanic eruptions, mud slides and avalanches.

Using the physical environment to produce energy from sources like fossil fuels, organic materials and alternative energy sources like solar energy, wind energy, nuclear energy and chemical energy.

Sustainable development of natural resources, using the water resources and preventing its contamination.

Global changes in climate.

In recent years, the environmental concept of the Earth Science is found more frequently under the Earth Systems approach. This approach refers to planet Earth as a whole where man is an integral part of Earth's natural systems, which are tightly combined and include the Geosphere, Hydrosphere, Atmosphere and Biosphere. This holistic approach, which based on combining in depth knowledge and comprehensive observations of all the components of the Earth can lead to a solution for the environmental problems our planet has to face.

During the 1990's there was a paradigmatic change in Science teaching in the Western world. This change can be seen in the shift from the paradigm that considered Science teaching to be a training tool for future scientists to the paradigm that considers Science teaching as a tool for the educating future citizens.

One of the existential challenges with which the citizens in the 21st century have to deal with is their ability to coexist peacefully with the environment. The teaching of Earth science and environment has a central role in teaching environmental literacy. The Earth Science endow the student, the future citizen, with knowledge and ability to draw conclusions about energy saving effective use of energy sources, saving water and proper use of Earth's resources.

Students, who understand their environment and its processes better, will be able to judge and evaluate the transformations and the changes that occur and as a result will behave in a better way.

There is no doubt that combining issues such as energy sources, producing raw material and natural resources, forecasting and coping with earth quakes and volcanic eruptions, water sources and changes in climate in the syllabus is the appropriate response to the call from both the professional community and the public to the teaching of science in its social – environmental context.

The implementation of the Earth System approach means that the traditional emphasis of earth sciences teaching should change. It should move towards the development of an Environmental insight and not just granting Environmental awareness. The development of an Environmental insight entails the teaching of three key principals:

- I. We live in a cyclic world made of a few sub-systems (Geosphere, Hydrosphere, Atmosphere and Biosphere) that coexist as a result of the material and energy that pass through them.
- II. Humans are an integral part of the natural system and therefore should act according to the cyclic natural laws.

Operative Objectives

In order to achieve the goal of the acquisition of an Environmental Insight the new program posts the following objectives:

1. To acquire basic knowledge about the physical systems of Earth in composition, structure and the active processes inside them.
2. To recognize and understand the reciprocal relations of the transfer of energy and matter in and between the Earth systems including the Biosphere.
3. To understand the place of the human system as part of the Earth systems.
4. To acquire basic scientific research skills of making an observation and the ability to discern between an observation, a conclusion and an assumption.
5. To develop thinking aspects which are unique to Earth science: Thinking in a geological time dimension (Deep Time), spatial thinking and three-dimensional thinking.
6. To develop the skills which are needed in order to develop an environmental insight: Cyclic thinking and System thinking.
7. To use Earth science as a tool to illustrate chemical, physical and biological principles.
8. To cultivate the connection with the natural scenery while understanding the uniqueness of Earth.
9. To understand the causes of natural hazards and their interrelationships with the human activity on earth.

In order to achieve these goals, the preparation of students towards the Earth sciences Olympiad should be based on the following principles:

Contents Principles for preparation students for the IESO

There will be an emphasis to deal with Earth Science contents in a system context linked to the geo-biochemical cycles on Earth. For example, "The rock cycle in Earth's crust ", "The hydrospheric cycle" "The carbon cycle".

The dealing with unique thinking skills concerning the Earth systems approach will be integrated with the contents and not separately.

Pedagogic Principles for preparation students for the IESO

Active learning. The student will construct the knowledge and its understanding in a process known as inquiry-based learning. Consequently, the school laboratory and the outdoors will be central components in the learning process.

The learning process will develop from the concrete to the abstract.

The outdoors learning environment will be a mandatory component of the curriculum.

It will deal with developing the following thinking skills where the Earth and Environment Sciences have a relative advantage:

- Taking observations and being able to discern between observation, assumption and conclusion.
- Three dimensional thinking skill.
- The development of the Deep Time dimension.
- Thinking simultaneously within the time and space dimensions.
- The development of cyclic thinking.
- The development of system thinking.

Skills and Abilities students should acquire towards the IESO

To be able to reconstruct in the field the sequence of geological processes that took place in the area being able to discern between an observation and a conclusion.

1. To be able to locate a geospheric phenomenon in the sequence of processes of the rock cycle.
2. To be able to do cyclical thinking in context of matter cycles in the Earth systems.
3. To be able to identify the components of a specific system (One of Earth's Systems) and to characterize each component in size, rate and complexity.
4. To be able to think systemically in order to understand the interaction between a specific system (One of Earth's Systems) and the development of interwoven interactions among the components of the system.
5. To be able to identify the interactions among the components of a specific system (One of Earth's Systems) as dynamic processes of the transition of matter and energy.
6. To be able to identify a specific system (One of Earth's Systems) as a cyclic – circular system in which the total amount of matter is conserved and the transition of matter does not occur on an equal rate.

7. To be able to identify dynamic processes in the time dimension while discerning among different time types, e.g., human time, historical or geological time.
8. To be able to identify environmental problems and to suggest solutions based on the understanding of the principles of the reciprocal relations among and inside the Earth systems.
9. To be able to think scientifically and make the distinction between an observation and an experiment, conclusion and hypothesis, the ability to hypothesize, draw conclusions and suggest solutions.
10. To be able to collect data from written and computerized sources, to process it with the appropriate software and to present it via graphs, charts, diagrams, drawings and concept maps.
11. To be able to represent and present knowledge in writing and orally using various means like research reports, a scientific poster and a computer presentation.
12. To be able to forecast and prevent the natural disasters such as earthquakes, volcanic activity, typhoon/hurricane, tsunami, landslides, and flooding"

B. The syllabus of the International Earth Science Olympiad

1. The Geosphere and Earth Systems

a) Key Ideas

1. Matter transition in and among Earth systems has to do with transitions between reservoirs (from one form to another). For example, the cyclic sequence – lithification, uplift, erosion, transformation, sedimentation, burial etc., creates a continuous "Rock Cycle" in which the total amount of matter remains constant, but its form changes when passing from one reservoir to another.
2. Earth's matter passes in a cyclic way between the different reservoirs while changing from one form to another. The matter passes in and between the different Earth systems: The rock system (rock and ground) - Lithosphere; The air system - Atmosphere; The water system - Hydrosphere; And the biological system - Biosphere.
3. The energy sources that activate the "Rock Cycle" are internal energy, conserved in the crust of Earth (radio-active disintegration), and external energy - solar energy.
4. There is reciprocity among the different Earth systems. For instance, erosion of rocks and the formation of soil are largely affected by the components of the Biosphere system like plants, fungi, worms and germs.
5. The formation of part of the residual rocks is tightly linked with biosphere processes. As a result, the sequence of rock layers has evidence to evolutionist processes (including mass extinction) that took place in the Biosphere, at the same time there were changes on Earth along the time line.
6. Changes in the crust of Earth whose source is internal energy, can be sharp and fast and occur on short notice (earth quakes and vulcanization) but can be very slow (the rising of mountain ridges). The changes in the Geo-sphere create a chain reaction in all the Earth systems, which may affect evolutionist processes in the Biosphere system.
7. The movement of plates expresses movement of matter and energy in Earth.
8. Earthquakes and volcanic eruptions, that take place mainly along plates' borders, are part of the mechanism of the transition of matter and energy on Earth. These geosphere phenomena have great influence on men and the rest of the biosphere system.

b) Skills and Abilities

1. The ability to identify the following igneous and metamorphic rocks: granite, rhyolite, basalt, andesite, gabbro, schist, gneiss, marble, quartzite.
2. The ability to identify the following igneous and metamorphic minerals: Quartz, orthoclase, plagioclase, biotite, muscovite, garnet.
3. The ability to identify rock structures such as porphyry, pegmatite, tuff, scoria, obsidian, lineation, and foliation.
4. The ability to identify in the field igneous bodies like a volcano, lava flow, dyke, sill.
5. The ability to understand the global meaning of local igneous and/or metamorphic phenomena in the context of the plate tectonic.
6. The ability to identify the following sedimentary rocks: limestone, chalk, chert, clay, marl, dolomite, sandstone, phosphorite, gypsum, salt.
7. The ability to define the following minerals: calcite, clay, halite, gypsum, pyrite.
8. The ability to identify the main composition of a soil.
9. The ability to identify in the field structures like layering, graded bedding, cross bedding, ripple marks, discontinuity planes.
10. The ability to identify in the field folding and faulting structures and to analyze the stress field that influenced the rocks (direction of pressing and stretching).
11. The ability to identify fossils and various forms of fossilization.
12. Making schematic cross sections along the Pacific, Atlantic and Indian Oceans.
14. Explaining the rock cycle in the plate tectonic terminology.
15. Making a schematic cross section through the earth (from the surface till the core)

2. Hydrosphere and Earth Systems

A. Main Ideas

1. There is a direct link between the geosphere and the hydrosphere systems. The water composition and availability are direct products of the rock composition and the geological structure and many geological processes are conducting through the hydrosphere media.
2. The soil composition and the rate of the seeping of the water influence many factors in the Biosphere system starting with floods following by amounts and kinds of vegetation and all the way to the availability of water to all living creatures, humans included.
3. Atmospheric phenomena and processes have influence on water dispersal and the frequency of precipitation.
4. The amount of water available for human consumption is limited. Uncontrolled actions can cause an irreversible damage (In relation with biosphere time and the pace of the adaptation of the biological world to this change) to water resources and a drastic decrease in the amount of water available in a certain area in human life span.
5. The composition of oceans water and their physiographic structure are the immediate product of the reciprocity with the geospheric system.
6. It is acceptable to assume that Earth's original hydrosphere had fresh water exclusively. The evolution of the composition of oceanic water is the result of water's quality as a universal soluble and the quality of solubility of minerals.
7. Oceanic origin catastrophic events like tsunami and hurricanes are the results of interactions among the earth systems.

B. Skills and Abilities

1. The ability to identify and characterize the hydrosphere system as intertwined in the earth systems.
2. The ability to identify environmental problems and to suggest solutions based on the understanding of the hydrosphere system.
3. Understating the mutual connections among the oceans, the Lithosphere, the Hydrosphere, the Atmosphere and the Biosphere.
4. Understanding the mutual connections between man and ocean.
5. The ability of systemic thinking in regard with the oceanic system in context with all Earth systems.

3. Atmosphere and Earth Systems

A. Main Ideas

1. The radiation from the sun causes warming of all of Earth systems, but the rate of absorbing and radiation of heat in rocks (Geosphere), water (Hydrosphere) and air (Atmosphere) varies from one to the other. This phenomenon creates, at the end of a complex process, local and global flow systems in the Atmosphere (wind) and oceans.
2. The composition of the primary atmosphere of earth was mainly the result of gasses that were emitted by volcanoes. The evolution of the atmosphere is intertwined with the evolution of life on Earth.
3. For hundreds of millions of years the atmosphere keeps a more or less similar composition as a result of the mutual relations among the atmosphere with the hydrosphere (oceans), biosphere (photosynthesis and breathing) and the geosphere (gas, volcanic dust and erosion).
4. In the short term human actions cause minimal imbalance in the atmosphere, but in the long term the oceans will become huge sinks that regulate part of the atmosphere composition. Since the biosphere is affected in the short term, even minute and temporary changes can cause terminal changes to part of the biosphere.

B. Skills and Abilities

1. The ability to distinguish between the components of a geochemical system, to identify mutual relations and to construct a network of interactions among them.
2. The ability to identify the interactions between the parts of the system as dynamic processes of matter and energy.
3. The ability to identify environmental problems and suggest solutions on the basis of understanding the principles of the geobiochemical system.

4. The Planetary System and Earth Systems

A. Main Ideas

1. The earth systems are a sub-system in the general planetary system - the solar system and it is impossible to get a full picture of the earth systems without understanding the processes of the passage of matter and energy between the solar system and planet earth.
2. Earth is one example in the solar system for the mutual relations that exist between the geosphere and atmosphere systems but there are more examples in other planets.
3. What we can see from here, we can't see from there and vice versa. The earth systems research allows better understanding of planetary systems in general, whereas research of other planetary systems helps to understand better the earth system.
4. The energy balance of a planet includes external energy - sun radiation, the influence of the sun gravitation and of close planetary bodies, and internal energy - as a result of the core activity, radioactive elements and internal processes.

b. Skills and Abilities

1. The ability to identify and characterize the planetary system as a system where the general amount of matter and energy is conserved.
2. The ability to compare data of the planets and draw conclusions about structure and composition.
3. The ability to identify the mutual connections among earth and the rest of the components of the solar system.