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FROM THE EARTH TO THE UNIVERSE: A TEACHING PROPOSAL ABOUT BASIC CONCEPTS IN EARTH SCIENCES AND ASTRONOMY FOR COMPULSORY SCHOOL.

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Resumen

We will present an innovative way of teaching about Earth and the Universe in compulsory school, based on a phenomenological approach and on the development of transversal and intertwisted pathways between Physics, Astronomy and Earth Sciences.

The main aim is to familiarize the students with the idea of a systemic and a dynamic planet interacting with the other celestial bodies. Depending on age, the history of interacting systems is described and interpreted in terms of stories, models, variables and correlations among variables. Students are stimulated to participate through active cooperative work to field observations, data analysis, construction of interpretative models and theories at different levels of formalization. Results of first testing of this teaching proposal in some selected classes (students 6-11 and 11-14 years old) will be discussed.

The research: framework and main aims

The main assumption of our research[1] is that it is possible and necessary to guide the process of knowledge construction about basic concepts and procedures of science, starting in kindergarten and

continuing through the all school years. Teachers of different school levels have to guide students along a coherent longitudinal and transverse path from their initial knowledge toward the scientific one. According to the “design studies” methodology (Confrey, 2006) the researchers of our group construct “conceptual corridors”: we re-think the topic to teach, then design pathways about a selected topic pointing out basic ideas and attitudes (Balzano et al, 2005; Duschl et al, 2007). Researcher -teachers construct “teaching trajectories” inside the conceptual corridor, so in different classes a variational testing of the initial proposal is made. Based on data collected in these laboratory-classes a revision of the proposal is made.

We present here the results of our rethinking about astronomy and earth sciences for compulsory school (students 4-14 years old) and the basic steps of the teaching proposal.

The fundamental idea that we think has to be constructed, at the appropriate level since kindergarten, is that the Universe and the Earth planet are unitary dynamics systems composed by various subsystems characterized by their own properties and their own kinematics / behaviors but at the same time interdependent and closely interconnected.

We have designed a set of landmarks that can help to guide the student through this conceptual corridor (Confrey, 2006), starting from learners' prior knowledge and arriving:

- to imagine the Earth interior, different from the outside, determining the nature and disposition of the geologic bodies and to reconstruct the processes (mainly occurred in the inner of the Earth) that have formed the geological body that we can see at the surface;

- to place the events inside a temporal framework (geological/astronomical time);

- to understand some common geological and celestial phenomena (volcanoes, earthquakes, mountain formation; night-day cycle, seasons, lunar phases, eclipses) and describe them in terms of the relative motions, positions and orientations of the Earth, the Moon and the Sun;

- To describe the kinematics of the Solar System in different reference frames;

- To understand the properties of the Solar System Planets and other celestial bodies

- To introduce first scientific ideas about Universe history and evolution.

Basic approaches and methodology

We propose an observation-data collection approach side by side with different forms of description/representation/interpretation, where students are stimulated to participate through active cooperative works to the development of ideas and interpretative models, starting from the everyday experience and from our location on the Earth. (Catalani, Giordano, Rossi, 2008).

Under a careful mediation by teachers, during the data collection on “near” and “far” objects and the construction of interpretative models, students can learn to recognize the systems, to describe them in terms of the main variables (shape, dimension, mass, composition, orbital motion, rotation and revolution periods, etc) and to find the dynamical relations in time and space between them.

As the celestial and geological events, cause of their complexity, are not directly governable from the man neither reproducible in laboratory, the observation acquires a fundamental role. The observation needs of long times (necessary to recognize the cyclic nature of the astronomical phenomena), spaces at various dimensions and instruments that allow to extend our sight and perception in space (inside and outside the Earth) and in time.

Observations on our planet

Working in the environment students are invited to collect, handle and study soil, minerals, rocks and fossils, recognizing composition, structure and disposition of the components to interpret the way in which the materials record and conserve trace of the events (the history of the rocks).

The construction of three-dimensional static and dynamic models becomes fundamental in order to help to reproduce not perceptible structures or phenomena. In this way it is possible to lead students towards the scientific interpretation, on the base of personal "concrete experience", not forcing them to move exclusively on a abstract plan. The study of rocks or volcanoes, for example, can be proposed to students giving them geological samples to manipulate and analyze, arranging experiments (like crystallisation) and constructing dynamic models of eruption, melting, solidification, etc. (Onida & Segalini, 2006). Understanding the volcano eruption mechanism (or the rocks' formation) should carry students to wonder about the deep origin of the melted material and of inner energy, motivating them to discover the Earth interior and stimulating them to put the different parts in a dynamics and causal relationship.

Looking at the sky

The astronomical path starts by the naked-eye observations of Sun (with eye protection, Moon and Stars above the local horizon at different hours of a day and at different days in the year. Then a geocentric point of view is constructed using models like the “parallel globe[2]” or comparing the local data with those acquired by students living in other places on the Earth. To pass from the observational plan to the interpretive one from the geocentric as well as the heliocentric point of view we suggest to use body-plays, real models and digital supports.

To introduce the idea of formation and evolution of the Universe the narrative style is used. Assuming the physical study going on parallel to the astronomical one, the observations of spectra can be introduced to speak about the Sun and stars composition, the distance-luminosity relation, the idea of an expanding universe in more and more deep and scientific sense.

Conclusions

Both section of the path (astronomical and geological) were designed, then tested in laboratory-situations as classrooms, stages on the field, courses for teachers' preparation. The variational procedure of the design study allowed to construct a conceptual corridor and to suggest teaching trajectories with particular attention to longitudinal and transversal coherence among school years and disciplines. Examples from the teaching trajectories will be presented to share methodology and results of our teaching proposal with the international community, to discuss and to get suggestions for further revisions .

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[2] a globe with the rotation axis oriented toward the North celestial pole seen from the observation location, so to be parallel to the axis of the celestial sphere around the observer.

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