

Earth-Science Education: From all over the World to East-Timor

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Introduction

Earth Science education (ESE) emerges as a relatively new research area and there is an unquestioned need for improving students' abilities on that field (American Geological Institute, 2008), taking into account that it is important for students' everyday lives and thus, relevant for scientific literacy. So, the inclusion of a section concerned with this issue, was a very wise decision of the 1st Geological Congress at East-Timor Organising Committee, revealing an up to date vision about education for the XXI century.

The paper will be divided in four sections:

- Science Education - meaning, epistemology and rationale;
- Earth- science-education all over the World in the context of Science Education;
- Earth- science education in East-Timor secondary school curriculum;
- Earth-science education and challenges for the future.

Science Education - meaning, epistemology and rationale

Science is an activity that all children from all cultural and ethnic backgrounds should participate in and "own". Moreover, the teaching of science through practical activities involving students is a source of enthusiasm and motivation. If teachers do not see science as a worldwide and humanistic phenomenon, they will continue to see the science and the technology in a way reinforcing inaccurate stereotypes (Dennick, 2002). Therefore, science contents are relevant despite not exclusives. Scientific processes and the procedures concerned with appropriate ways of learning are also under discussion. Science Education (SE) is the field concerned with sharing science contents and process with individuals not traditionally belonging to the scientific community. The standards for SE provide expectations for the development of students' understanding through the entire compulsory education. The traditional subjects included in the standards are physical, life, Earth, and space sciences.

About the science approach, research has been revealed that students' and teachers' perspectives about the nature of scientific knowledge influence the way how they learn and teach, respectively (Nadelsen and Viskupics, 2010; Praia and Cachapuz, 1999). Learning subject content is dependent of the epistemologies used in the classroom and so, educational events can be viewed as practices with their own epistemologies. Through the last three decades there has been a shift from "content" to "process" or from "science as knowledge" to "science as a way of finding out" (Amos and Boohan, 2002).

Research also suggests a set of common rationales for SE: (a) the utilitarian - an understanding of science is crucial mainly to anyone living in a knowledge society; (b) the economic - connection between the level of public scientific background and the nation's economic health; (c) the democratic- decisions have to be made about disposal of waste, energy policy, minimised effects of mineral exploitation, loss of natural beauty,...; (d) the cultural - science should be celebrate as cultural domain (Millar, 2002).

Synthesis of this section. The authors emphasize three guidelines rooted on educational research for the designing of science curriculum: science contents, methods of enquiry used in science and science as a social enterprise.

Earth-sciences education in the context of SE

In the following of both the reflection and guidelines referred to above, a set of assumptions, for ESE emerges:

- . the Earth works as system with humans as a subsystem contrasting with the idea of distinctness of man from the natural world (Mayer, 2003);
- . the understanding of the Earth must be holistic across both space and time (Frodeman, 2003);
- . the Earth seen as a system often with the various system cycles as components of the organizing framework (Orion 2003);
- . the core concepts fundamental to reasoning and inquiring in the Earth sciences include scale - deep time and space, energy - gravitational, thermal, tidal and solar sources, matter transformation - rock cycle (Duschl, 2006);
- . the Earth-science curriculum should be about "common things" in both the natural and man-made world which have relevance at the personal, family, local, regional, national and global levels (Thompson, 2001).

These “common things” and some of the “core concepts”, for example, help to understand that Earth-science is at one and the same time concrete and abstract to the learners. The flowing streams, the outcrops with strata, the soil we dig in, the mineral and rocks picked up in the field all contribute to the familiar phenomenon of our sense perception view of the Earth and its processes. The continental drift or plate tectonics, at least their mechanisms, the age and origin of the Earth, even the geomorphologic evolution, are counter intuitive in real time.

As far as the earth science curriculum is concerned, these concrete and abstract views should be included on it - focusing, on the one hand on developing an understanding of geological processes and events at specific places and times and, on the other hand on guiding principles of an holistic perspective of the planet, enabling a systems analysis of the Earth.

In this context, recalling “science as a way of finding out”, one is faced with two rationales for the importance of the Earth science in the curriculum:

- . contribution for understanding the way how the Earth works;
- . promoting, through an interdisciplinary approach, the habitability and sustainability of the Earth towards the definition of policies of management concerning land use and land planning. To achieve this, sustainability education must be truly interdisciplinary involving physics, chemistry, biology, even politics, economics or philosophy.

Despite ESE could be seen as a very young research area, as it was already stressed, a tremendous amount of work has been done since early 1980s of the 20th century. In the context of SE research, very strong evidences have been revealed that students enter in their science classes with ideas about the natural world that do not correspond with accepted scientific findings. Topics such as, for example, the Earth and the solar system, origin of the Earth, volcanoes, earthquakes, geological time, continental drift, plate tectonics have been under scrutiny (Bonito *et. al.*, 2011; Dahl, Andersen and Libarkin, 2005; Marques and Thompson, 1997). The diagnosis of these preconceptions may be seen as a crucial, initial step in the process of teacher facilitated conceptual change at all grade levels. To develop conceptual change, educators may employ new ways of constructivist teaching based on assumptions of cognitive learning (Bonito, 2008). Emphasis on inquiry processes in the curriculum promoting problem solving (Soares de Andrade, 2001) seem to be a powerful procedure to develop students’ competences towards the growth of citizenship.

The validation of the results obtained related to this new research area is mainly carried out, as usually at the scientific community, in SE scientific meetings. Nevertheless, the authors think that it is fair to underline, particularly in the context of this paper, the role played by the International Geoscience Education Organization (IGEO), affiliated to and sponsored by IUGS. The main goal of the organization is to promote ESE internationally, at all levels. The last IGEO Conference - GeoSciEdVI - took place in 2010, at the University of Witwatersrand, at Johannesburg. The several areas of the Conference are here indicated, for giving a flavour related to what has been done in ESE research so far: best practice in ESE; ESE in the real world; teaching difficult and/or controversial geoscience topics; ESE in informal settings; using computers and multimedia to teach about geosciences, geoheritage, different social economic and political contexts; collecting/analysing/modelling geoscience data; using Earth sciences Olympiads as a tool to promote ESE.

Synthesis of this section. ESE is now a novel research area concerned with an holistic view of the Earth, using SE methodologies and contributing with suggestions for a designed curriculum which is supposed to reach an accurate view about the way the Planet works and, therefore, about its sustainability.

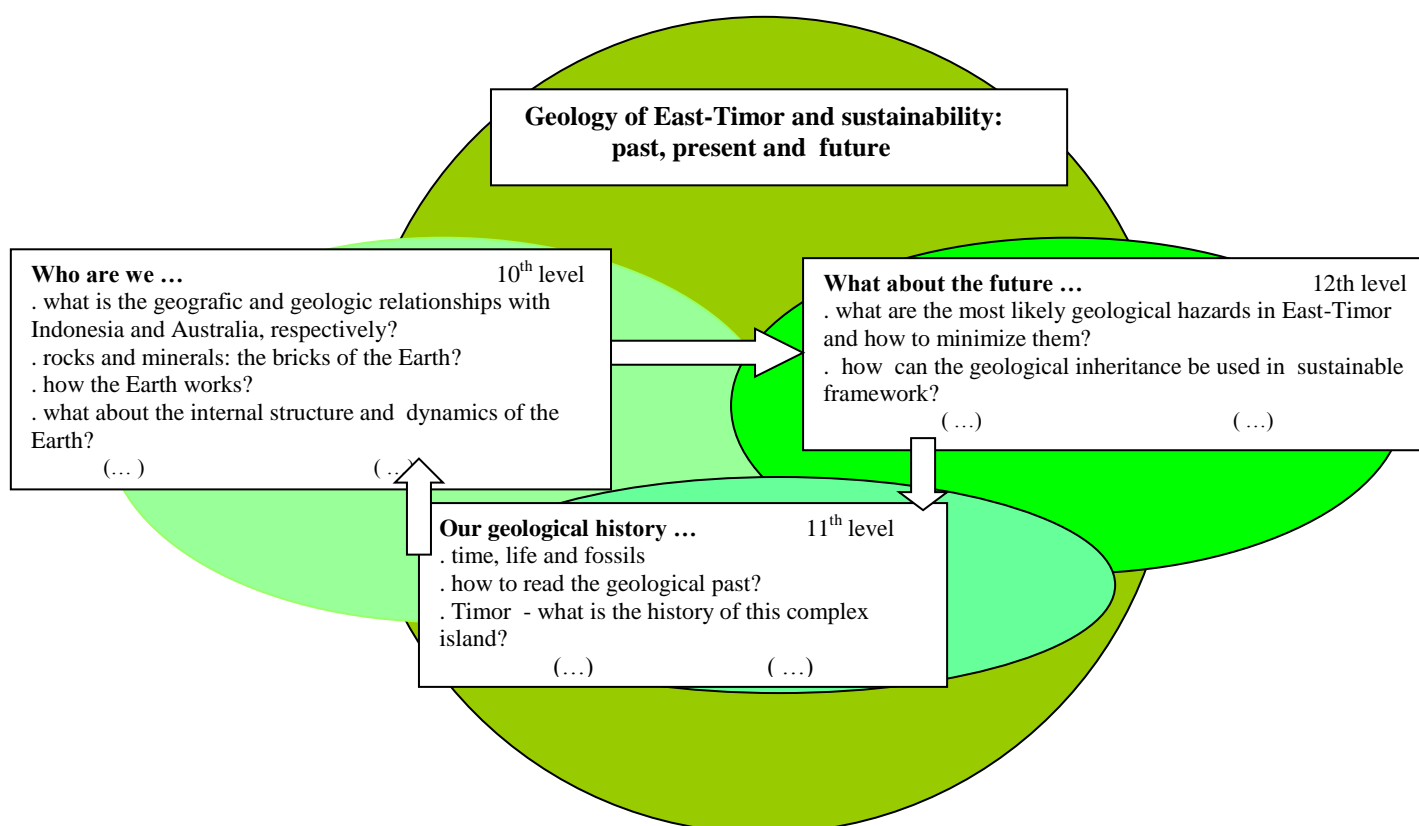
Earth-science Education in East-Timor secondary school curriculum

Politicians with high responsibility in East Timor have been arguing, across time, that Education is on the top of their priorities. The *Education National Plan 2007* and, particularly, the plan *Timor-Leste Plano Estratégico de Desenvolvimento 2011-2030*, underline that high educational standards are needed to contribute to the growth of the country. This is the political context in which the **Reestruturação Curricular do Ensino Secundário Geral em Timor-Leste (2011)* was requested by the Minister of Education of East-Timor to the Calouste Gulbenkian Foundation. The University of Aveiro, through a large group of experts coordinated by Professor Isabel Martins, has the scientific responsibility for the designing of this ambitious programme. Programmes, textbooks and teachers' guides for all disciplines are also being written by the group of specialists. Considering the nature of this paper, the authors find important to quote from that new curriculum:

- . one of the principles – to use guidelines from the Decade of Education for Sustainable Development, United Nations Literacy Decade and Millenium Development Goals (p. 13);

. one of the objectives - to promote the role of the multidisciplinary scientific knowledge towards the understanding of local, national and global problems (p. 16).

The figure below shows (in strong articulation with the previous sections) the three main sequential dimensions of the Geology curriculum for the triennial (10th-12thlevel) and under a common organizer *Geology of East-Timor and sustainability: past, present and future*.



The 10th level (see the figure) is organized in four didactic units and focus both, on the idiosyncratic location of East-Timor and on the approach of core geological concepts - (a) to live together; (b) the Earth - egg and egg-shell; (c) rocks and minerals: the bricks of the Earth; (d) deformation of rocks - the strengthen of the Earth.

In relation to the 11th level, it is mainly concerned with the history of the Earth and also with the past of Timor. Four didactic units are suggested and the main subjects taught are as follow: (a) deep time as a complex and core concept for geologists; (b) the role played by fossils as organic traces buried by natural processes; (c) reconstruction of the presumed geographic and geological issues of the past; (d) analysis of geological heritage of East-Timor mainly based on maps.

Regarding the 12th level, an attempt to face the students with several geological issues, mainly related to East-Timor itself will be done. Three units are put forward: (a) geology and society: hazards and resources; (b) geological hazards stressing those which can occur in the country; (c) geological resources, emphasizing oil origin, storage, usefulness and sustainable exploitation .

Synthesis of this section. We should emphasize that, as it is quite common, the discipline begins by teaching learners to broad concepts and fundamentals and then, apply for understanding either the way the earth works or a few geologic aspects of this country. In addition, it is the authors' expectation that the curricular topics and the approached methodologies can help the articulation between secondary and tertiary education.

Earth-science education and challenges for the future.

Interest in a specific area of science is highly correlated with the perceived benefit. We expect that Geology topics, increase students' interests in probing the secrecies of nature and motivate their concerns about environmental problems - local and around the world - reinforcing a citizenship attitude. This achievement would be facilitated through an approach well articulated with other scientific areas in a holistic way i.e. in a Gaia perspective (Lovelock, 2007). Another contribution of the referred to above topics is the development of students' competences, such as critical and independent thinking, to pursuing their courses at tertiary education.

No doubt that all of the above requires extensive investment in science teacher education, both in pre-service and in-service. Taking into account that teachers deal with young people from all walks of life on a daily basis for many years, they play a crucial role in the students' development of competences planning science approach, i.e. earth science, in a social, moral, spiritual and cultural context. The lack of experience of earth science teaching at East Timor science secondary curriculum reinforces the challenge of teachers' education for this knowledge area. Geology contents and pedagogical content knowledge are teachers' crucial achievements.

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