EARTH SCIENCES EDUCATION: AN EXTRA DIMENSION TO SCIENCE EDUCATION IN SCHOOLS

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ABSTRACT

The first International Geosciences Education Conference which took place in Southampton, UK, delivered very clear messages with respect to science education in shools 5-19. In an era when environmental issues play a crucial role in the ability of the humankind to live safely on planet Earth, there is a need to provide our children - future citizens and hopefully wise democratic voters - with a more than skin deep familiarity and understanding of the working of our Planet. This need is far from being satisfactorily achieved: the teaching of Earth sciences in schools all over the world shows shining examples of good practice but is patchy at best and non-existent at worst. The educational potential of the Earth sciences is very high and the small but effective community of Earth science educators increasingly has the knowledge to fulfil of this potential in practice. There is an urgent need for extensive efforts in curriculum development, teachers' training and educational research in Earth science education. Without the coordination of these activities worldwide it will not be possible to elevate Earth sciences education to the place it deserves in the schools' science curriculum. The science education establishment (which rarely include Earth science educators) does not provide the Earth science education with the resources needed for entering to schools. Truly professional science educators must realize that their job is not only to perpetuate what already exists, but to open their hearts and minds to potential contribution from all kinds of sources. Science education betrays is obligation to society if it fails to respond to the need of the general public to understand the working of Planet Earth. Science educators should accept that to include more Earth sciences investigations into science curricula will serve not only to redress a balance but will enrich science education generally: it will give it extra dimensions and

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make it more relevant and enjoyable for pupils. The science teaching community cannot and should not remain indiferent to the low profile of Earth and environmental sciences in schools. On the basis of the importance of the Earth and environmental sciences and their educational potential we must all cooperate to build a new these missing links in the science education of world citizens of the 21st century. However, we should not just wait till the science teaching community will see the light. The whole earth science community namely educators and professionals should unit together to advance this process.

RESUMO

EDUCAÇÃO EM GEOCIÊNCIAS: UMA DIMENSÃO EXTRA PARA A EDUCAÇÃO CIENTÍFICA ESCOLAR. A primeira Conferência Internacional sobre educação em Geociências que ocorreu em Southampton (Inglaterra) transmitiu uma mensagem muito clara a respeito da educação científica na escola para a faixa etária de 5 a 19 anos. Numa era em que as questões ambientais desempenham um papel crucial na habilidade da humanidade para viver em segurança no planeta,há necessidade de fornecer a nossas crianças - futuros cidadãos e, espera-se, eleitores democráticos conscientes - mais do que familiaridade e compreensão superficiais do funcionamento da Terra. Essa necessidade está longe de já haver sido satisfatoriamente atingida: o ensino de Geociências na escola, no mundo todo, apresenta brilhantes exemplos de boa prática, mas em geral é fragmentado (na melhor das hipóteses) quando não inexistente. O potencial educacional das Geociências é bastante alto e a pequena, mas eficiente, comunidade de educadores dessa área tem o conhecimento crescente para colocá-lo em prática. Há necessidade urgente de amplos esforços nas áreas de organização curricular, formação de professores e pesquisa em ensaio de Geociências. Sem a coordenação dessas atividades em escala mundial não será possível elevar a educação em Geociências ao nível que ela merece nos currículos escolares de ciências. O sistema de educação científica (o qual raramente inclui educadores de Geociências) não favorece o ingresso da educação geocientífica nas escolas. Os verdadeiros educadores profissionais devem perceber que seu trabalho não se resume a perpetuar o que já existe, mas abrir seus corações e mentes à contribuição potencial de todos os tipos de fontes. A educação científica trai sua obrigação para com a sociedade se falha em responder à necessidade do público em geral de entender o funcionamento do planeta Terra. Os educadores científicos deveriam aceitar que aumentar a carga de atividades de Geociências no currículo científico escolar servirá não apenas para reequilibrar o balanço, mas também para enriquecer a educação científica em geral: fornecerá dimensões extra e a tornará mais relevante e prazerosa para os alunos. A comunidade de educadores científicos não pode e não deve ficar indiferente ao fraco desempenho da educação geocientífica e ambiental na escola. Baseados na importância e no potencial educacional das Geociências e Ciências Ambientais devemos cooperar para construir essas novas e ausentes ligações da educação científica

dos cidadãos do século XXI. Entretanto, não devemos esperar até que a comunidade de educadores científicos veja a luz. A comunidade de Geociências como um todo, educadores e profissionais, deve se unir para fazer avançar esse processo.

INTRODUCTION

Earth sciences education is the neglected child of the science education family. Despite this, the first international conference on Earth science education in schools took place in April 1993 in Southampton, UK, as one of the four themes of a general International Geoscience Education Conference (IGEC). The conference was very well attended with over 260 participants from about 55 countries from all over the globe. More than 65 papers were delivered during the sessions on the theme of Earth science education in schools. It seems likely, therefore, that this situation of neglect will soon change and Earth sciences education will begin to receive more emphasis in many countries throughout the world.

The worldwide survey of Earth science education in schools revealed that its status is increasing considerably but is still far from that of other science disciplines and even further from the status that it deserves.

There are many reasons for the relatively low profile of the Earth sciences education in schools. One of them is the lack of knowledge of many of the professional leaders of science education of the nature and the essence of Earth sciences and even less of them are aware of the great educational potential of the Earth sciences as a scientific discipline.

This paper addresses the earth scientists community, both, educators and professionals and the general science educators' community as well and it has three main purposes:

a) to provide earth science educators with facts and ideas which will hopefully help them to pursue and advance earth science education in their local situation.

b) to arise earth science researchers' awareness to their influence on the educational decision makers and to encourage them to take an active role in advancing earth science education in the pre college educational field.
c) to inform the general science educators' community of the high educational potential of Earth sciences education and to stress the need for more emphasis to be given to this domain in schools.

THE NEED FOR EARTH-SCIENCES KNOWLEDGE AND UNDERSTANDING

The Earth sciences involve us all - every man, woman and child - in the study, investigation and understanding of our own planet -- Planet Earth; its lithosphere, hydrosphere, atmosphere, biosphere and its position in space. On the one hand the Earth sciences are involved in locating, describing and exploiting the key resources for the survival and welfare of humankind and on the other hand they are concerned with understanding the nature and origin of natural and man-made hazards.

Furthermore, about 30 years ago, the earth scientist has established an one all embracing major theory - the Plate Tectonic theory. This theory has provided one of the most important scientific breakthroughs of our generation which serves to explain the working of our planet.

Surprisingly, this quantum jump in our understanding of our world and our environment, as well as the importance of the earth sciences in our daily life, have not been echoed in the educational system of most countries. All over the world our children -- our future citizens -- leave schools ignorant of the most basic matters relating to their planet and hence are handicapped as voting citizens in their decision-making abilities concerning local, regional and global environmental issues.

THE EDUCATIONAL POTENTIAL OF THE EARTH-SCIENCES

Regarding to the most important scientific issues involved in the Earth-sciences, delegates to the conference stressed that the overall purpose of Earth-sciences education at ages 5-19 is to educate for citizenship rather than, or as well as, to prepare students to become professional geoscientists. The aim should be to maximise personal development and to increase the cognitive and ethical understanding of all the citizens with respect to the workings of the global environment and the exploration for and the exploitation of resources.

Conference members stressed that this goal could be achieved only if the very high educational potential of Earth and Environmental sciences could be realised in schools, in terms of the following considerations below.

Scientific Thinking

The Earth-sciences encourage pupils to be scientific detectives through the development of intellectual and practical skills, attitudes and methodologies that relate to problem solving.

The role of conjecture, the creation of multiple working hypotheses, the designing of investigations, the making of relevant observations, the development of a variety of recording skills: predicting, testing of ideas, inferring, interpreting and the communicating of findings; induction, deduction and falsification all have their role to play.

To unravel processes that took place millions of years ago, the geologist has developed a distinctive way of thinking -- involving retrospection i.e., using knowledge of present day processes in order to draw conclusions from clues and pieces of information about the rocks of the Earth's past which are combined together like a jig-saw - to create a clear picture of the materials, processes and environments of past times. This particular contribution to the students' cognitive abilities together with the development of spatial visualization skills, is almost

unique to the Earth-sciences education to an extant which is rare in other science disciplines (Kali & Orion,1996).

The Time and Space Dimensions

The Earth-sciences use and develop concepts common to the traditional sciences, and some which are uniquely their own, in a conceptual framework which ranges from local to global and involves the depths of time and the vastness of space. This large time range, measured in millions and billions of years, and the huge spatial domains above and under the Earth's surface are the objects of study: inner space, near space and even outer space are involved (when comparison with other solar and planetary systems are considered).

Environmental Education

Today, more then ever, there is a worldwide recognition that living in peace with our environment is more than just a slogan, it is an existential need. It is also agreed that the understanding of each of the earth's sub-systems and the environment as a whole is indispensable in order to live in peace with the environment. This understanding is actually what science all about.

Earth-science has a major part to play in the environmental education of society. It gives the students -- our future citizens -- the knowledge and the ability to reason about the importance and interrelationships of the lithosphere, atmosphere and hydrosphere as well as subjects such as the utilization and conservation of energy, water and material resources. There are two main schools of looking at environmental studies. Both approaches look over the interrelationships between man and the physical environment, however they differ by their perspectives. One school is more concerned with the understanding of the physical environment. Studying the five interacting Earth's subsystems or spheres - atmosphere, biosphere,

cryosphere (ice), hydrosphere and lithosphere. The other school is more concerned with the environmental hazards from the human life perspective. This approach gives more concern to the interrelation between energy and environment. For example, the exploitation of our limited energy resources their overly utilization effects on the environment. The human society, for this approach, is an integrated part of the earth systems. Technology has dual part in the societal-environmental interaction. On the one hand, the technological revolution and the over-using of energy resources, dramatically increased the damage of some aspects of the environment, but on the other hand, new technologies can help in limiting environmental hazards and in providing alternative energy resources.

Most importantly such studies deepen the students' awareness of their physical surroundings and homeland and enable them to participate in an informed way in contentious matters as exploitation versus conservation.

The Interdisciplinary Nature of the Earth-Sciences

The Earth-sciences, by their very nature, form an interdisciplinary approach to problems. Physical and chemical processes and principles and biological processes and environmental understanding are used to explain geological phenomena relating to the present and the past. Therefore, the Earth-sciences demonstrate the practical uses of physics and chemistry in our daily life.

They also have close relationships with biological topics such as evolution, ecology and the links between rock-soil-flora and fauna.

The concept of the Earth as a system - the Earth System - as defined by USA governmental earth science research agencies, provides a conceptual model for curriculum developers to use in promoting integrated science programmes (Mayer, 1993). The majority of research efforts of all the science disciplines relate to Planet Earth. Therefore the Earth System approach is the best and most appropriate focus for such integrated science courses.

From the Kindergarten to the High-School

By classifying the learning concepts from the "concrete to the abstract", Earth-sciences topics can be presented appropriately to students of all levels of ability, achievement and age from the kindergarten to the high school.

The use of many learning environments in the teaching-learning process: Earth-science allows the integration of formal teaching in several learning environments: the classroom, the laboratory, the field, the museum and the industrial site. Many presentations at the conference relating to fieldwork delivered to the Schools Theme emphasised the importance that is attached to reforming and redeveloping this kind of work amongst the geoscience education community. The amount and variety of such work totalled more than in any other area of interest. Members related how former teaching strategies, which were essentially "lectures in the field" had given way to student investigative work of a wide and varied kind. These latter strategies were devoted to work in the field as a means of concretisation of facts, processes and experiences, as well as an introduction to the field research methodology (Orion, 1993; Orion & Hofstein, 1994). This work was matched by assessment procedures which allowed both the processes and the products of students' work to be assessed by the teacher on the spot and moderated by an examination board later.

The Relevance of Science to Our Daily Life

There is a wide agreement among educators generally that the teaching of science which relates to an individual, to daily life and the local environment is a very powerful teaching strategy. The applications of the understanding of the Earth-sciences are direct and relate to many important aspects of life, for example in studying natural disasters (earthquakes, volcanic eruptions, landslides, hurricanes, sea defenses, etc.), the mining of raw materials (potable water, coal, oil, gas, construction materials etc.), the control of energy resources (fossil fuels, nuclear,

tidal, solar etc.) and the care of the local, regional and global environment (concerning landscapes and environments e.g., the preservation of wetlands or tropical forests, the greenhouse effect, the ozone layer, rising sea levels, etc.).

IF IS ITS EDUCATIONAL POTENTIAL SO HIGH, WHY IS ITS STATUS GENERALLY SO LOW?

The worldwide survey of geoscience education in schools at the conference revealed many shining examples of individual good practice, often associated with the activities of one or a few vigorous and imaginative persons working against all odds. However, overall geoscience education is patchy at best and non-existent at worst.

In many countries the only geoscience education evident was associated with geographical traditions and pedagogy, and this was said to be a rapidly rising, hitherto unknown force, in the USA. In USA, Venezuela, UK, Southwest Europe, Australia, Israel, Korea and Japan, Earth-sciences in science education for secondary level pupils aged 11-19 was more or less formally introduced and this was noted with approval by most delegates. In most continents and countries geoscience education, and science education generally, was not greatly developed for pupils aged between 5 and 11, except in Japan, Australia, UK, USA and recently in Israel. The new national curriculum of England and Wales includes some earth sciences topics as an integral part of the Broad Balanced Science (BBS) curriculum (King, 1993). The inclusion of Earth sciences in this curriculum undoubtedly broadens it, but the relatively small proportion of these subjects, which were eventually included, against heavy pressure from traditional science lobbies, makes this version of BBS sadly unbalanced as well.

Thus, overall both the scientific importance and the high educational potential of the Earth sciences are rarely expressed in the reality of schools' curricula.

The analysis of all the reasons which may contribute worldwide to this situation is beyond the scope of this paper but we can point out, at least, three main factors:

a) The lack of a critical mass of Earth sciences educators.
b) The lack of acquaintance with the Earth sciences and the unawareness of the values this area amongst the leaders of the international science education fraternity.
c) The relatively limited involvement of academic earth scientists with pre college education.

The revolution in science education in relation to research and curriculum development which started during the 1960s, involved only very few Earth sciences educators mainly in USA. As a result, very little was done to introduce Earth sciences subjects to the science curricula even in the USA and even less about the development of teaching and learning strategies for schools' pupils. One of the most important findings of the Southampton conference was that this situation is no longer the case. Dedicated and active Earth sciences educators exist today in many countries all over the world. However, their activity and influence on the multitude of educational systems are often limited by members of the science education establishment.

There is a tendency, however, as reported at Southampton, for established bodies in many countries to question the basis of present curricula and practices and increasingly to welcome hitherto non traditional and more relevant scientific sub-disciplines, concepts and ideas and and more effective teaching-learning strategies. The entry of Earth sciences to schools still depends very much on the Earth sciences educators providing initiatives, but it also greatly relies on the warmth of welcome offered by the educators of the established science disciplines who control the curricula, budgets and examination procedures. Their willingness to recognize the Earth science education as an equal member of schools' science is still, alas, a long way off. The Southampton conference revealed that the state of Earth sciences education in many countries often receives much sympathy and that there is a

growing awareness of the desirability of introducing more of it into schools. Unfortunately, this support is usually still theoretical and involves mainly lip service. In practice, Earth sciences education receives only the crumbs of the cake in relation to teaching hours, resources for the development of new curriculum materials, funding for research and teacher training. The aggressive territorial "behaviour" of the science education establishment towards Earth sciences education is understandable in the light of the past practices and the workings of human nature, but it cannot be understandable in the light of the scientific importance and the educational potential of Earth sciences as we all approach the 21st century.

THE ROLE OF THE PROFESSIONAL GEOSCIENCE COMMUNITY

It is well known that active scientists have a great impact on the content of science curricula, all over the world. Unfortunately, earth scientists are rarely involved or interact with educational systems. The prominent role of the professional part of the geological community in the introduction of geoscience into the curricula is well exemplified through the Israeli experience. The decision of the Israeli Ministry of Education in 1985 to recognize Earth-Science as an independent scientific discipline was granted only as a result of the initiative and efforts of a single scientist (Prof. Emmanual Mazor, a geologist-geochemist from the Weizmann Institute of Science). It was this man who later opened the doors of the Department of Science Teaching of the same Institute to earth science educators. The policy decision in 1990 of the universities to give Earth-science matriculation results an equal weight to those of other scientific disciplines when accepting new students, resulted from the efforts of an academic lobby for geological education. The decision of the Hebrew University of Jerusalem in 1992 to open a new program for the educational training of Earth-science teachers was a direct result of the efforts of members of the Geology Department of the Hebrew University.

The geoscience community needs to appreciate that ultimately, budget cutting or growth are determined by politicians who are influenced by public

opinion. Thus, if one is not involved in bettering society, one cannot expect to be understood and hence be supported by the society. The educational channel is the best way to deliver the message that understanding geoscience concepts is of vital importance in our daily lives.

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