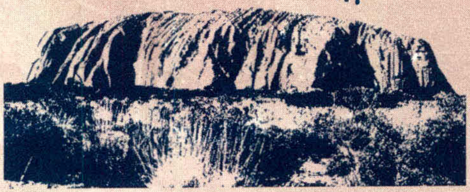
ABSTRACT VOLUME

GeoSciEd III



3rd INTERNATIONAL CONFERENCE ON GEOSCIENCE EDUCATION

GeoSciEd III
dedicated to teaching & learning

16-21 JANUARY 2000,
University of New South Wales,
SYDNEY, AUSTRALIA

AGSO Record 1999/49

Third International Conference on Geoscience Education

GeoSciEd III
dedicated to teaching & learning

CONFERENCE PROCEEDINGS

University Of New South Wales
January 16-21, 2000

The Australian Geological Survey Organisation, as a major sponsor of this Conference, has published these Proceedings in agreement with the convenors.

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Ian F. Clark, Editor

Past and Future Conferences

First International Conference on Geoscience Education and Training, April 1993, Southhampton, England. Proceedings edited by DAV Stow and GHJ McCall and published by AA Balkema Publishers, Rotterdam, The Netherlands.

Second International Conference on Geoscience Education, July 1997, Hilo, Hawaii.. Proceedings edited by Rosanne W Fortner and Victor J Mayer and published by the Ohio State University, USA.

The Fourth International Conference on Geoscience Education will be held in Clagary, Canada 17-20 August 2003.

Welcome to GeoSciEd III

Dear Conference Participant,

A very warm welcome to Sydney for the GeoSciEd III Conference on behalf of the development committee for the International Geoscience Education Organisation (IGEO). Following the success of the first International Geoscience Education Conference in Southampton in 1993, and the second in Hawaii in 1997, we have every expectation that GeoSciEd III will not only be very successful but will also be able to build on the solid foundation laid down by the other two conferences. The conferences have allowed us to build an international network of those interested in Earth science education across all the continents. The support and encouragement of the international community have been important elements in several national initiatives over the years. If this support could help you in your own situation, you just have to ask.

The conferences, and the network that has developed from them, have allowed news, good ideas and important developments to be shared with the Geoscience education community worldwide. We are particularly pleased, in this context, with the success of the website and the newsletter. John Carpenter has done an excellent job for us, in not only setting up the website but by maintaining it by adding our newsletters as they appear. The newsletter is now in its fourth edition, and has been circulated far and wide, both electronically and by mail. Items from the newsletter have been relayed to even wider audiences through national publications. We should particularly thank Laure Wallace and Mary Dowse, the newsletter editors, for their hard and effective work in encouraging contributors and in putting it all together. Thanks also to Montse Domingo for translating the newsletter into Spanish, so that it reaches an even wider audience. We are very grateful to all the contributors as well, without whom the newsletter could not exist.

The year 2000 and the Sydney conference will be very important to IGEO because this is the time and place where we anticipate that IGEO itself will be inaugurated. The development committee will be pleased to hand over responsibility to a duly elected organising committee with an agreed constitution at the important meeting on Thursday (18th - 5.30). We hope you will be there to take part in this momentous occasion and to share your views on where the Organisation should be going and how this can be achieved. Meanwhile, we would like to thank all those members of the development committee for their efforts since Hawaii, that have brought us this far. They are Ian Clark (Secretary and Conference Organiser), Frank Ireton (Treasurer), Laure Wallace and Mary Dowse (Newsletter Editors), Alan Morgan (next Conference Organiser), John Carpenter, Montse Domingo, Yoshisuki Kumano, Arlei Macedo and Ravi Shankar.

GeoSciEd III in Sydney could not have happened without the great deal of hard work that has already been put in by many people. We would like to thank the local committee for all their efforts so far. They are Malcolm Buck, Ian Clark, Gary Lewis and Sonia Cousins, who have been ably assisted in recent months by Kathleen Kemp (Kathleen will also be closely involved in the running of GeoSciEd IV). Thanks to their efforts, and the efforts of all those others who are running field excursions and workshops and preparing the conference facilities, we have a splendid programme in prospect. We hope that they will not only survive the hard work of the conference itself, but also find time to enjoy themselves. Indeed we hope that everyone will have the chance to meet old friends and colleagues, to share experiences and build relationships, and to have a thoroughly memorable visit to Sydney and to the various field excursion venues.

The international network that has become IGEO has already achieved a good deal, but we hope to move on from Sydney, building networks, relationships and support groups that will develop Geoscience education, at all levels across the world. Our long term goal remains to bring effective Earth science education to all school pupils and to those in Higher Education who want to develop their interests in the Earth further. We hope that you too will continue to support Earth science education, both nationally and internationally, and become an important part of IGEO in the future.

Our next big occasion will be GeoSciEd IV planned for Calgary in Canada for 2003. We look forward to seeing you and many others there, carrying Geoscience Education forward into the new millennium.

Best wishes for a very fruitful conference,

Chris King and Nir Orion (Co-Chairs, IGEO Development Committee)

Section 1

Abstracts for oral Presentations

Teaching Geology Relevant to Environmental and Sustainable Resource Management: A Paradigm Shift in Geoscience Education

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Introduction

Unlike other branches of sciences such as biology, chemistry and physics, geology has remained, since the beginnings, poorly understood by the general public, and indeed by most other professionals and scientists. This poor understanding is partly due to the way geoscience has been taught at the tertiary level. Historically geoscience education has focused on a relatively narrow field of specialisation dominated by the exploration and production paradigm. As a result, the traditional educational system produced highly specialised professionals unable to demonstrate that geology is also relevant to other issues of concern to modern societies such as environment protection and sustainability. Consequently, the current geoscience education has contributed to the creation, inadvertently, of rigid walls around the discipline which inhibited nongeologists taking interest in or even making attempts to understand geology.

Another impediment to the promotion of geological science beyond the specialised circle has been the recent decline in the demand for tertiary geoscience education. As most of the mineral deposits, fossil fuels and other geological resources have been discovered or depleted, traditional employment opportunities for geologists have become fewer. As a result, many geological departments in universities around the world have been closed or merged with other allied departments during the past two decades. All of these, point out that this declining trend in the tertiary geological education will continue in the future. Consequently, the traditional geological education in Australia and the world has become even less relevant to the wider community.

This paper attempts to outline a number of concepts and strategies that the author believes, if adopted, would make a significant contribution to reverse the trend of relative indifference of the general public to geological science and set the foundation for a long lasting phase of growth and development in the geoscience education and employment.

A Change of Paradigm in Geoscience Education

As indicated above, traditional education paradigm has focused on exploration geology and production of energy, mineral deposits, groundwater and related resources necessary to meet the ever growing demand of the socio-economic development. This educational paradigm has not only failed to attract interest from the general public in the discipline, it is leading, in the long term, to a dead end. To overcome this challenge, we must seriously consider adopting a new educational paradigm to expand the scope of geoscience teaching in order to make the discipline more relevant to the aspiration of a wider constituency. The new educational paradigm should aim to produce graduates with considerable lateral thinking and ability to deal with problems that transcend the traditional boundaries of the discipline.

Environmental science and sustainable resource management (ESSRM) provides a valuable opportunity to effect the desired paradigm change in geoscience education for two important reasons. First, ESSRM is dynamic and provides several open-ended opportunities for growth, development and community interest. Second, geology and earth science can provide a much needed foundational framework to assess and understand a whole host of causal factors and processes that are critical to ESSRM (Al Bakri 1998 and Al Bakri and McInnes 1999). To date, there has been very limited interest by geologists in ESSRM for the following reasons:

- Geologists do not normally get involved in ESSRM because their training does not assist them to understand the important role of geology in ESSRM.
- Professionals who are involved in ESSRM tend to have very little training in geology and therefore they are unable to appreciate the need for geological inputs to ESSRM.
- Most of the available geological maps and literature are not user friendly to non-geologists and, despite their immense value to ESSRM, they are rarely used in related investigations.

Geology and ESSRM

Application of geology in ESSRM has been primarily limited to issues related to engineering and geotechnical works, natural hazards, and groundwater pollution. These areas represent a small component of the enormously broad field of ESSRM. Geology is the most critical causal factor influencing the intrinsic characteristics of all land attributes. Therefore, geology and related earth science processes play a very important role in determining the inherent constrains and subsequently the potential and resilience of any biophysical system. By studying geology, we should be able to develop genetic models that can explain, predict and diagnose a wide ranging issues related to land and water resource sustainability (Al Bakri and McInnes 1999, Al Bakri 1998). Some of the ESSRM issues that critically need geological inputs but do not receive much attention from geologists are :

- Soil formation and its in situ characteristics
- Soil degradation and land management issues such as:
  - Soil salinity
  - Soil sodicity
  - Erosion & structural stability
  - Soil acidity
  - Soil fertility decline
- Water quality and water resource management issues such as:
  - Water salinisation
  - Eutrophication & algal blooms
  - Water acidification
  - Turbidity, sedimentation and chemical pollution
- Agriculture use and practice
- Environmental impact assessment
- Land use planning and site selection
- Coastal zone management
- Sand encroachment and desertification control.

A number of papers have been published by the author and his co-researchers to provide details and case studies to demonstrate the role and importance of geoscience to the above ESSRM issues (Al Bakri and McInnes 1999, Al Bakri *et al.* 1999, Al Bakri and Chowdhury 1999, Al Bakri 1998, Al Bakri *et al.* 1997 a & b, Al Bakri and Chowdhury 1997, Al Bakri 1996, Al Bakri 1994).

Recommendations

To achieve the proposed paradigm shift in geoscience and its tertiary education system, it is recommended that:

1. Geological departments in the Australian universities put in more effort to include in their curricula, subjects on the role and importance of geology to ESSRM.

2. Geological departments offer user friendly and specifically designed geological subjects to meet the need of the educational curricula of other disciplines that are concerned with ESSRM.

3. Professional organisations and institutions concerned with geoscience should take initiatives to encourage research and publications that deals with application of geology to ESSRM.

4. Geological departments and professional bodies should organise conferences, workshops, and training courses to geoscientists, land managers and resource users to enhance their understanding and appreciation of geology to ESSRM

5. More concerted effort should be made to develop simple methodology and models to help land and water resource users and managers employ geological maps and available geological information in assessing sustainability.

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The Development of Earth Sciences in Philippine Science High School: A Case Study

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The Philippine Science High School system is the country's premier high school in providing scholarships to students wishing to pursue studies in science and technology. Until recently however, earth sciences did not receive as much attention as did other basic sciences such as biology, chemistry, physics, and math. Earth science was taught as part of the Introduction to Physical Sciences subject in first year. With changes in the curriculum that have accompanied the expansion of PSHS into several regional campuses, students pursuing the "science stream" (as opposed to the "technology stream") took up an Earth Science subject. Established in 1995, it is handled by the physics department and is taught throughout the year. With the success of this first step, the subject was expanded to include all freshmen, starting in the schoolyear 1998. Most recently, it has been added to the general curriculum that all the regional campuses have now adapted.

But aside from the creation of this new subject, students now avail of other opportunities to develop their awareness of geology. In large part this is due to several projects initiated by the Geological Society of the Philippines, which counts several PSHS alumni as its members. The sponsorship of career talks, seminars, and summer training programs are but some of the activities which have drawn the attention of students into learning more about geology.

Although other high schools have earth science subjects in place, these are still basic in scope. The experience of PSHS in developing its earth science program can serve as a model for other schools, including local science high schools, in developing and expanding their respective programs

Cognitive Aspects of Studying the Water Cycle in an Environmental Context.

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For the last several years, we have been developing a new earth science curriculum for junior high school students. This curriculum is based on the earth systems approach and includes a unit about the hydrosphere. We designed this unit within an earth systems context in order to help students achieve environmental insight. Such insight is largely based on understanding the cyclic mechanisms of our planet. Our main goal is that students should be able to translate environmental problems, such as water pollution into a more coherent understanding of the environment. With such understanding, students might hopefully see the environment as a series of interacting subsystems, with each influencing the other.

In order to fulfill these goals, we chose the water cycle as the unifying concept of the curriculum. The curriculum materials present the water cycle as a part of a wider set of recycling systems, which include the geosphere, the biosphere and the atmosphere. Environmental problems are presented within the context of this relationship between the hydrosphere and the other components of the earth systems. It might be added that this relationship is shown to be a result of the transformation of matter (especially water) between the different systems.

The development of the new curriculum unit was preceded by a predevelopment study. A formative evaluation followed the completion of the first implementation phase.

The predevelopment study:

The predevelopment study included the following two objectives: a) to identify junior high school students' previous understanding of the water cycle. b) To explore the students' perceptions of the cyclic and systemic nature of the water cycle.

In order to collect the needed data, a series of research tools were developed for this study, including interviews as well as open and closed questionnaires. The following is a brief description of these research tools:

A questionnaire for Assessing Students' Knowledge (ASK):

This questionnaire includes two parts: Part A includes a Likert-type questionnaire, where students were asked to mark their level of agreement with a list of statements concerning the water cycle. The following are two examples: *(1) "The composition of a* *cloud, which has formed above the "Sea of Galilee" is different than a cloud that has formed above the "Dead Sea".* (2) *"Underground water is actually underground lakes that are located within rock".* In Part B, the students were asked to draw the water cycle. For this task, they were provided with a list of the main stages and processes that are included in the water cycle and they were instructed to incorporate as many of these items within their drawings.

A Cyclic Thinking Questionnaire (CTQ):
In this Likert type questionnaire students were asked to mark their level of agreement with a list of statements concerning the cyclic nature of the hydrosphere and the conservation of matter within the earth systems. The following are two examples: *(1) "The amount of water in the ocean is growing from day to day because rivers are continually flowing into the ocean". (2)"Clouds are the starting point of the water cycle and the tap at home is its end point".*

Interviews:
Interviews were conducted with 40 students, once they had completed the questionnaires. Interviews had two main objectives. It served as a tool for validating the students' answers on the questionnaires; moreover, it provided greater insight into students' perceptions of the water cycle. During the interviews, each student was requested to read his answer, and to say whether he still agreed with his drawing and then to elaborate on his answer.

Approximately 1,000 junior high school students (7^{th}-9^{th} grades) from 30 classes in 6 urban schools participated in the predevelopment study. Analysis of the predevelopment questionnaires indicated the following:

1. Most of the students possessed an incomplete picture of the water cycle, which contained many misconceptions about it. Children that drew the water cycle usually represented the upper half (evaporation, condensation and rainfall) and ignored the ground water system. More than 50% of the students could not identify components of the ground water system even when they were familiar with the associated terminology. In their mind, underground water is seen as a static, sub-surface lake and water solution chemistry is fixed throughout the entire water cycle.
2. A significant correlation was found between cyclic thinking and those drawing of the water cycle which included the groundwater component.
3. Analysis of the predevelopment study suggests that the students' ability to perceive the hydrosphere as a coherent system depends on both scientific knowledge and cognitive understanding. Scientific knowledge is composed of two elements: a) Factual-based knowledge that includes acquaintance with the components of the water cycle and awareness of its processes. b) Process-based knowledge, namely a deep understanding of the various processes that transform matter within the water cycle.
   Cognitive understanding is also composed of two elements: a) Cyclic thinking: Understanding that the water cycle is a system which has no starting or end points, and moreover, that the same matter is transformed many times within the system. b) Systemic thinking, which is the ability to perceive the water cycle in the context of its interrelationship with the other earth systems.

The development phase

The findings of the predevelopment study served as a basis for the development of the interdisciplinary program, "The Blue Planet". This program focuses on the water cycle as an example of the relationships seen amongst the various earth systems. It emphasizes a systemic approach by addressing the following elements:

1. Presenting a coherent depiction of the various processes (chemical, physical, geological and biological) which effect each stage of the water cycle.
2. Relating the water cycle to the different elements of the earth system.
3. Presenting the water cycle in a Science Technology and Society (STS) format.
4. Using constructivistic methods to alter the students' misconceptions of the water cycle.
5. Using computers to access global data bases so that the students will better understand that the water cycle is a worldwide phenomenon.

The program also focuses on the role of man within the water cycle. To fulfill this goal, the following subjects were included:

- ☑ Availability of water resources for human use.
- ☑ Man as a part of the water cycle.
- ☑ Surface water and ground water resources.
- ☑ Human involvement in preserving water quality.
- ☑ Understanding Israel's water needs.
- ☑ Sustainable development and water resource management.
- ☑ Water as an ecosystem.

Evaluation of the first implementation phase

This study examines the effect of studying the water cycle, and it's connection with man, on the development of environmental insight among Junior

High School students. More specifically it focused on the following:

1 . Exploring students' conceptions and attitudes concerning man's relationships with the earth system.
2 . Identifying the types of alternative frameworks students possess concerning the various components of the water cycle.
3 . Identifying changes in knowledge and cognitive skills developed by students who were exposed to the "The Blue Planet" program.

The research population of this phase included 700 Junior High School students that studied "The Blue Planet" program. In this phase, we used research tools based on those used in the predevelopment study. In addition we added the following two tools:

Concept maps.
The students were asked to create concept maps at the start and finish of the learning process. Comparison of the number and type of items within the concept maps served as a measure of change in the students' knowledge and understanding of processes. The number of connection within the concept map served as an indication of students' understanding of the relationship between the components of the water cycle.

Observations.
In order to track the learning event itself regular observations were conducted in the classes. The observer used a structured observation report that directed her to document the type of activities of both students and the teacher.

Findings:

The following are the findings from the evaluation study of the first implementation phase:

1. Our observations indicated that for the most part, the teachers concentrated on scientific principles and largely bypassed the cognitive aspects of the connections between the water cycle and the other earth systems. In addition, most of the teachers tended to ignore the constructivistic activities that were specifically designed to correct students' misconceptions, as well as to develop a broader and more coherent perception of the water cycle within the earth systems context.
2. A significant improvement was found in the students' level of knowledge (specifically acquaintance with the components of the water cycle).
3. The students significantly improved their understanding of the evaporation process. However, in relation to all the other processes only a minor improvement was found.
4. The students showed some improvements in their understanding of the different types of interrelationship among the earth systems. However, even after learning the program, students still have a poor understanding of the systemic nature of the water cycle. Most of the students showed a fragmented perception of the water cycle and make no connections between the atmospheric water cycle and the geospheric water cycle.

Conclusion:

These findings indicate that improvement in knowledge for its own sake is not enough to develop environmental insight. It is suggested cognitive abilities in cyclic and systemic thinking might lead towards this purpose. In this study, we found that although such activities existed, teachers tended to ignore them. Thus, more effort should be invested in teacher training in order to convince teachers that better knowledge for itself does not contribute to the types of cognitive thinking skills that are necessary for gaining environmental insight.

Geology at Auckland Museum

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Auckland Museum is currently undergoing an intensive refurbishment programme. Five galleries have been set aside for Natural History. Four galleries are presently open to the public with the fifth due for completion in December 1999.

The Origins Gallery tells New Zealand's story as a journey through time. The next two galleries, Land and Oceans, take the visitor on a topographical journey from mountain top down to the shore and out to the sea that surrounds us. The Human Impacts Gallery looks at the effects we humans have had on the land and its native inhabitants. The Maori Natural History Gallery will explore the interpretation of the natural world by Maori. Throughout these developments, Geology has maintained a supporting presence, providing the physical and temporal background to the biotic narrative.

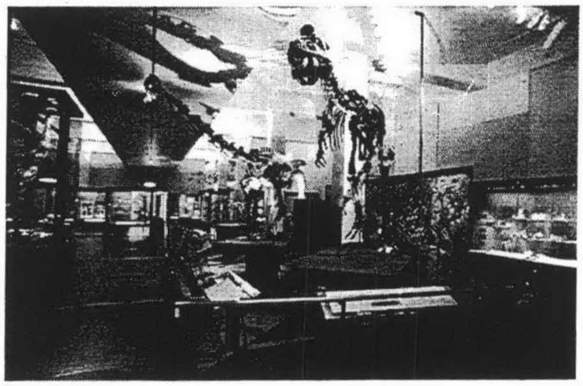
The Origins Gallery is divided into two parts. The first half sets the scene, describing basic concepts such as geologic time, Earth's structure, stratigraphy, and plate tectonics. A computer interactive exhibit has been developed to explain the concept of plate tectonics, using animation to show how the continents move. Rich displays of fossils illustrate the evolution of life during the Paleozoic and Mesozoic

The key dividing event is the formation of the Tasman Sea and the separation of New Zealand from the supercontinent Gondwana. A plasma screen video animation of the breakup of Gondwana combines separating continents and changing biota, reinforces sea floor spreading and discusses the end-Cretaceous mass extinction event.

The second part of the Origins Gallery concentrates on New Zealand as an isolated landmass during the Cenozoic. The extinction of the large reptiles and the absence of land mammals allowed the birds to dominate, making it a 'Land of Birds'.

A computer interactive display gives the visitor an opportunity to discover the changing shape of New Zealand through the last 45 million years. Supporting displays deal with climate change and how this has affected our natural history. A display on volcanoes is supported by a 4-minute looped video showing different volcanic eruption styles.
These galleries are also used as part of Auckland Museum's formal education to schools. Auckland is a city built on volcanoes. Teachers representing a large number of schools with students from 5-18 years old rely on Auckland Museum's exhibits. A dedicated team of educators teach collection-based curriculum-linked programs. Written and hands-on resources are produced that cater for a range of learning styles. With curatorial help and using the galleries as a base, school education kits have been produced on Natural History, and one specifically focussed on Geology.

Origins Gallery



The Role of Field Trips in the Conservation of Geo-educational Land Resources (GEDULARs) in the Philippines

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Coined as *gedulars* (suggested pronunciation: *JHED-u-lars*), short for geo-educational land resources, here refer to land exposures such as rock outcrops, archaeological sites, mining sites, and other land bodies containing special geological structures or features which could be educational sites for students on a more permanent basis, i.e. they could be visited as an established extension of the classroom and have a "niche" in the school curriculum. The term could also include some museums, particularly those built at or near outcrops, and parks frequented by classes for lessons in the Earth Sciences or related fields. One such *gedular* is a pillow lava exposure near Manila, Philippines which has been actively degraded due to wanting conservation efforts especially from the government. Field trips on the site have been conducted to galvanize teachers and students of the need to conserve the outcrop.

Several field trips with teachers who underwent in-service training in our Institute, and students who had their enrichment classes were conducted primarily to make them aware of the significance of the geo-educational resources such as the pillow lava exposure. As the stark neglect to conserve the site is evident, such as the ubiquitous presence of garbage on the site and the vandalism on the pillow lavas themselves, the next step was to bring this to the attention of the local government. Reports of field trips indicating the teachers and students remorse and indignation over the environmental degradation of what could have been an excellent *gedular* for the schools near the site, even for schools in Manila and its environs. Moreover, letters written and signed by the teacher-participants and students have been forwarded to the office of the mayor containing expressions of concern, and suggestions and recommendations of how to conserve and develop the site for the learners of today and tomorrow. The government's action has yet to be seen but surely, the galvanized teachers and students have found a cause to fight for as a result of their own observation and knowledge about how awesome the formation of those pillow lavas was in the submarine environment millions of years ago . And it seems, field trips or, rather, field trips for a cause, could be instrumental in the preservation and/or conservation of these resources. Hopefully, this initiative coupled with concerted efforts from educators, teachers, and students would yield political actions, at least from the local governments, for the sustainable development , not only of the pillow lavas, but of other geo-educational resources, especially those undergoing degradation which are not so difficult to find in the Philippines and , perhaps, in other countries as well.

Earth System Science: The Unicamp Students Understand the Way the Planet Works

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Introduction

Geography and Geology are the careers opened to the students who follow the Undergraduate Program *Earth Sciences* at Institute of Geosciences in the State University of Campinas. The disciplines *Earth System Science I* and *II* are offered during two successive semester-length and compose the core of two careers, i.e. the basic disciplines to be attended by every student. They comprise an integrated body of knowledge, aiming to adopt: (1) an articulated view of the contemporary knowledge on the several interactions in the terrestrial environment; (2) an interdisciplinary focus on the effects of human and social activities on Earth's surface. Such ideas on the nexus between technosphere and ecosphere need several approaches to see the Earth as a whole. Both disciplines are supported on different teaching capabilities.
The discipline was first taught in 1998; so, since the initial offering, they have been taught two times, because the course is new it is the first Geology undergraduate course created in Brazil since 1976. Students are conducted by a narrow line connecting both the "earth" and the "world" systems. The main theoretical-practical contents are presented on Table 1.

Teaching Earth System Science

Gijón (1988) pointed out some possibilities to develop a interdisciplinary program based on Geosciences. Domingo and Sequeiros (1998) stress that Earth Sciences knowledge helps to develop the integral education of every person.
Creativity is needed in a practical way of teaching as well as the skill to understand natural processes. Moreover, there is a high level of information on geoscience-related facts among existing professionals but there is evidence that they feel somewhat limited in dealing with complex and multidisciplinary problems.

Beyond describing natural features, events and cycles, a geoscientist must be able to exercise the analogical, inductivist, deductivist and multifactorial thought. The future professional should conceive and analyse systems, products and processes, using adequate models to produce an expanding number of geoscience applications. They must get the skill to translate onto maps the observed processes and the consequent features, allied to a domain of outstanding amount of new suitable info-technologies.
It is necessary to geologic mapping, geochemical and geophysical surveys or land-use planning, but also for planning the use of mineral, hydrologic and energetic resources as well. Nevertheless, a geoscientist will need to communicate with other people in his group of work as well as with people without scientific formation.
Interdisciplinarity also implies facing highly complex problems and performing the capacity of comprehension of a variety of concurrent parameters and processes. Interface projects require dealing with administrative, legal, social-economic and culture aspects of man and the environment. So, students need to know other *languages* (other sciences, cultures, politics, etc.) to discuss and to explain their point of view to someone else and to understand the social and legal languages.

Table 1 – The main conceptual units

Earth System Science I	
1	Foundations of Earth studies
2	Geosphere
3	Interaction of the fluid spheres
4	Biosphere and the interaction with the other spheres
5	Introduction to the study of the World System
Earth System Science II	
6	Geosphere and World System
7	The memories of the World System
8	World System as a work and as a norm
9	The inequalities of the World System: planetary regions

In this cultural and social context a program coordinating both Geography and Geology students need to be emphazised. It is also a powerful coexistence that promotes a new communication between social and natural researchers.
Geosphere: an example
The following example illustrates how our course used and related different concepts. We start from the main topic called *Geosphere* because it meets a varied techniques and strategies for teaching the Earth Science System.
To study geosphere is to understand the whole and the parts of terrestrial processes recorded in organization, disposition and composition of the rock spheres. At the same time, it implies understanding of relations among the rock spheres and the other ones (technosphere, biosphere, atmosphere, hydrosphere). Moreover, it is a typical

geological approach: to examine the history of the Earth by means of the rock records.

Our main worry is to contribute to develop a new view in front of rocks, minerals and the Earth as a whole. We believe that this attitude is connected with conceptual and skill capacities. To show up our approach we take the pedagogic design of *Geosphere* (Domingo & Sequeiros, 1998).

This design reveals that it is difficult to separate theory and practice-lab topics because we usually cross from practice to theory and *vice versa*.

The structure described here includes a variety of facets: (1) *Going from the familiar to the unfamiliar*. The way of instruction is based on the idea that a student in order to learn something must be able to attach the new idea to his own personal framework (for instance, to start the approach by the geosphere students can build their new ideas from fieldwork and natural hazards). (2) *Collaborative work in small groups*. Students have time to work together to answer questions that allow them to bounce ideas off each other and get beneficial effects of group thinking (during the development of the topics, students are called to compare and evaluate data and evidence which lead them to understand the theory of plate tectonics). (3) *Finding a general explanation for a set of data*. When students are presented to the variety of observations and questions engendered by focused point of view about the theory of Plate Tectonics, they are led to the general conclusion that perspective affects the selection of data. (4) *Science is constantly changing*. The challenges put to students reveal that scientific explanations were different ten years ago and, surely, they will be different next ten years too.

Table 2 - Schedule of activities developed along the Geosphere unit

Small group. Basic ideas on classification and seriation of the terrestrial materials.
Field Trip. The Moutonnée rock and sedimentary Carboniferous-Permian rocks related to Gondwana glacial deposits.
Debate: Carboniferous-Permian Glaciation and Continental Drift.
Reading. Take care: Earthquakes! Study on Afeganistan and Colombia.
Lecture. Distribution of modern seismic zones, origin of earthquakes and faulted terranes.
Movie. Why do you have still mountains?
Small group. Model of the Earth's interior.
Movie. The living machine.
Computer lab. Plate tectonics: how it works?
Small group. The modern structure of the geosphere.
Conference. Plate tectonics: its effects and implications for the Brazilian territory.
Small group. The forming environments of rocks and minerals.

This design generates a selection of main aims which are expected that students overcome until the end of Geosphere unit. The first group of aims are concerned to certain ideas and concepts:

1. To discuss the notion of geologic hazard related with seismic and volcanic terranes.
2. To recognize the main plate boundaries and to explain the main processes that happen there.
3. To discuss the theory of plate tectonics as an integration of two other explanations (continental drift and sea-floor spreading).
4. To recognize some records of glaciation in the field and to explain how they could have been originated.
5. To recognize some kinds of minerals and rocks and their respective common plate tectonic environment of formation.
6. To understand the processes associated to plate tectonics in the present and in the last 200 Ma.
7. To understand some relations among plate tectonics movements, its causes, its consequences to mankind.
8. To examine earthquakes, tsunamis and volcanoes within a double perspective: as a geologic hazard and as a natural consequence of plate movements.

The large number of aims can be explained when we consider that the Geosphere unit is 29 hours (the whole discipline is 90h). The scheduled activities are presented on Table 2.

Another set of aims are related with skills which students are expected to take on final *Geosphere* activities:

1. To observe, compare and discuss basic tectonic data related to the plate tectonics theory.
2. To collect relevant information on seismicity, volcanism and morphology of oceans and continents to defend plate tectonics theory.
3. To acknowledge some geologic thinking to make scientific models and explanations.

This perspective allows certain approach with social areas (something necessary for us). The value attributed from near to distant, from familiar to unfamiliar, plays relevant epistemological role: we can work with *landscape* idea. This is the way we found to deepen relations between geography and geology.

The essential point for us is to acquire an ethical attitude in front of natural processes, social events and their relations.

Discussion

There is a consensual view of the relevance of fieldwork. It is present in all stages of the process of generating the geoscience knowledge. The discipline only allows field trips. These aim to show up a confront between the environmental student knowledge and the different stages of scientific knowledge. From the students it is expected to understand the dynamics of the scientific research; they exercise a simulation by means of field activities (Compiani & Carneiro, 1993). In the field they are led:

to show up their own knowledge by observing and interpreting natural processes and geologic records (Nummer & Carneiro, 1998). Their first steps are given without teacher's help to they speak and register their own ideas. This understanding level can correspond at a hypothetical scientific moment of the science (Spencer, 1997).

to compare their own notions with systematic and scientific knowledge by means of discussions with teachers. This stage students change their ideas by scientific ones by means of mediation and changing of meaning.

The final understanding represents the actual idea about science and its practice: explanations, theories, hypotheses etc. are steps to undergo their own knowledge. Science is made by reformulation, debate and complementation. This is revealed by the history of science (Praia, 1996; Sequeiros, 1997).

The results are satisfactory to prepare students to so different professional careers (students can therefore work on urban geography or even mineralogy). Upon such approach the coordinate work reveal to be relevant enough in order to evolve the nature of Geography and Geology sciences and their research methods.

The interest of the students was high during *Geosphere* unit. We should remember that many students has poor interest in science. Although enthusiasm was not the same for every student, they were well-prepared to continue their course of Geology as well as Geography. We believe that it were a consequence of both didactic strategies and individual tasks.

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Educating for Sustainability

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I have been teaching environmental issues courses to undergraduate students and K-12 teachers for more than 25 years. During that time my approach to educating for sustainability has evolved and the time that I devote to this very important topic has increased significantly. In this presentation, I shall describe my approach to increasing the awareness of the concept of sustainability on the part of my students (undergraduates and K-12 teachers).

My approach to increasing awareness of sustainability involves comparing and contrasting two very different ways of looking at the relationship between Planet Earth and its human inhabitants - the Frontier World-View and the Sustainable World-View.

- The <u>Frontier World-View</u> is characterized as being **human-centered**. In this view, the Earth is seen as a limitless system. People holding to this view see *humans as separate from each other and from nature.*

- The <u>Sustainable World-View</u> is characterized as being **Earth-centered.** In this view, the Earth is seen as a **sustainable system** - one which is able to survive for a specified period of time by managing its population and resource utilization such that *it satisfies its present needs without jeopardizing its future needs.* People holding to this view see *humans as connected to each other and as a part of nature.* It should be noted that most successful non-human life forms adhere to the principles of a sustainable world-view.

These two "world-views" can be thought of as endpoints on a linear continuum. In reality, most people do not hold strictly to one or the other of these two view-points and the world-view of any individual probably lies somewhere along the continuum between these polar view-points. How an individual sees this relationship dictates the extent to which he or she becomes knowledgeable about a given issue, the level of concern that he or she feels about that issue, and the type of action (if any) that he or she will take to address the issue.

However, it is now clear to most geoscience educators that simple awareness of the concept of sustainability is insufficient if we are to address effectively such critical issues as depletion of non-renewable natural resources, global change issues, land use issues and the global increase of pollution in our air, water and soil. It is clear that we must do whatever is needed to engage our students in the process of taking constructive action, not just while they are in our classes, but also for the remainder of their lives. Therefore, I shall also describe in this presentation some of the strategies that I employ to attempt to create a lifelong commitment to sustainability.

- In courses for undergraduate students, most of whom are non-science majors, students can only earn a grade of "A" if they take part in some concrete action to redress some environmental concern, in addition to demonstrating increases in awareness and concern.
- In courses for teachers, participants must develop a two-week instructional unit for use in their classes.

While neither of these strategies guarantees that the students develop the life-long commitment that I am seeking in them, they do engage the students more actively to a greater extent than is normally done in more traditional classes.

The Development of a Problem-Solving-Based Computer-Assisted Instruction to Improve Earth Science Students' Achievement

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Abstract

The main purpose of this study was to (1) develop an earth science computer-assisted instruction (CAI) based on "presenting problem, planning solutions, collecting necessary information, carrying out plans, and evaluating results" five-staged problem-solving-based instructional model; and (2) to investigate the effects of the problem-solving-based CAI on earth science students' achievement. The investigation employed a pretest-posttest control group design to detect any significant change. A total of 151 tenth-grade students enrolled in four sections of a required earth science course participated in this study. During a two-week period, the comparison group (n=72) received a traditional lecture/discussion approach while the experimental group (n=79) received the problem-solving-based CAI. The *Achievement Test* was utilized to measure students' content achievement in earth science. Results of an analysis of covariance on posttest scores with pretest score as the covariate revealed that the problem-solving-based CAI did significantly improve the achievement of students to a greater degree than the traditional teaching method ($F = 4.90, p < .05$). This finding suggests that incorporating the problem-solving-based CAI into secondary schools have its promise in terms of improving students' earth science content achievement.

Introduction

Recent science education standards in the US propose that 'teaching must involve students in inquiry oriented investigations in which they interact with their teachers and peers. ... 'they apply science content to new questions; they engage in *problem solving*, planning, decision making, and group discussions' (National Research Council, [NRC], 1996, p.20). Many studies have indicated that problem-solving-based instruction results in greater student achievement than those strategies reflected in traditional science classrooms (Chang & Barufaldi, 1999; Geban, Askar, & Ozkan, 1992; Hall & McCurdy, 1990; Henkel, 1968; Mulopo & Fowler, 1987; Russell & Chiappetta, 1981). There were relatively few studies, however, which tried to improve pupils' content achievement through a problem-solving-based CAI within a classroom setting. This study addresses this setting.

Methodology

Subjects included 151 tenth-grade senior high school students attending 4 earth science classes in Taiwan. These students were typical of tenth-grade students with a mean age of 16; gender was equally distributed among the classes. To measure student achievement in earth science content, the researcher constructed and developed the *Achievement Test.* A panel of experts, including three professors and three high school teachers established content validity of the test. After conducting item analysis, thirty test items were included in the *Achievement Test.* The estimated reliability coefficient of the test was 0.77 using Cronbach internal consistency method. A pretest-posttest control group design (Campbell and Stanley, 1966) involving 151 students was adopted. The participants in both groups were tested before and after the two-week intervention. During the two-week period, each group received an equal amount of instructional time and was provided with the same instructional content and assignments. The problem-solving-based CAI developed and employed in this study emphasized the following five-staged problem-solving processes: presenting problem, planning solutions, collecting necessary information, carrying out plans, and evaluating results. The traditional instructional method in this study stressed direct lectures given by teachers, use of textbooks and other materials, and clear explanation of important concepts. The key feature of this "teacher-centered" instruction was providing students with clear and detailed instructions and explanations. The teacher undertook the task of transferring science knowledge to students. A number of variables such as tenth-grade earth science students, the same instructional content and assignments, and teaching duration were held constant. The independent variable was the method of instruction and the dependent variable was student content achievement. An analysis of covariance (ANCOVA) was conducted on the dependent variable with pre-treatment measure as the covariate to detect any significant differences between the experimental and comparison groups. A level of confidence was set at a 0.05 level of significance.

Results and Discussions

Results indicated that there are significant differences of students' content achievement in earth science between subjects in the experimental group and the comparison group after treatment (F = 4.90, $p < .05$) as shown in Table 1. The results of this investigation support previous work (Geban, Asker, & Ozkan, 1992), in which this study demonstrated positive effects of a problem-solving-based CAI on students' science (chemistry) achievement.

Table 1

Analysis of covariance on the posttest scores with the pretest score as the covariate.

Source of variation	*SS*	*df*	*MS*	*F*	*p*
Covariate	727.77	1	727.77	110.80	
Between groups	9.41	1	39.41	4.90*	0.028
Within groups	1191.07	148	8.05		
Total	2011.88	150			

*p<0.05

The finding of this study shows superiority of the problem-solving-based CAI in promoting students' achievement. Maybe it is because the treatment enabled students to solve problems at their own paces. Or it may be that pupils exposed to the problem-solving-based CAI were provided the opportunity to understand the problem, to identify any facts associated with the problem, to collect important data and information, to elaborate their solutions, and finally to solve the problem. This study generated evidence to support the notion that the problem-solving-based CAI is more effective in enhancing the *learning of earth science content* than a more traditional teaching method. It is therefore suggested that instruction such as the problem-solving-based CAI should be more broadly developed and widely employed in the secondary earth science classrooms.

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Online Communities for Earth System Science Teacher Professional Development

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Objectives or Purposes

Online courses consisting of communities of learners are experiencing increasing use and credibility. This paper outlines the design, development and implementation of three online earth systems science graduate courses. The themes of earth system science content and collaborative, student-centered science education prevail within an electronic environment where teacher participants take responsibility for their learning within a structure of clear expectations.

Open-ended, student-centered curricula in which students investigate problems, conduct research, make and support recommendations have received increasing attention. For example, the *Benchmarks for Science Literacy* (AAAS, 1994) cites the growing literature in the area of problem solving and recommends students develop habits of mind encompassing the knowledge, skills and attitudes supportive of effective problem solving. Among abilities recommended for student development are questioning, seeking answers, displaying curiosity and skepticism, viewing science and technology thoughtfully, using technical tools, and becoming critical thinkers during data interpretation.

Riel (1999) suggests we design online courses to model the student-centered environments discussed above. We accomplished this by modeling a collaborative, student-centered environment in which teachers relied on each other during group problem solving, online research, support, and constructive feedback. The purpose of the design was to provide an intense learning experience that would implicitly challenge teachers' prior learning experiences and explicitly develop their knowledge-building skills. These 16-week courses were created to provide professional development in earth system science for teachers in grades K-4, 5-8, and 9-12.

Perspective or Theoretical Framework

A primary concern during course design was in creating an online learning environment where interdependence among participants would provide the glue necessary for a successful community of learners. Interdependence is built as a result of a complex task, roles, shared resources, and joint products (Johnson, and Johnson, 1992). These courses are structured for interdependence by asking teachers to characterize the effects of an event such as a volcanic eruption, deforestation or forest fires on the earth systems, including the land, air, water and living things. Teachers develop individual expertise, then work in teams to examine first, second and third order effects of the event. The online environment provides spaces that support the roles and tasks — from discussion spaces to personal journals to product spaces. The spaces have scaffolding for the kind of thinking required for each task, such as "how to contribute to the conversation" for the discussion spaces, and criteria for how to be a critical friend. To provide this framework for supporting inquiry, we looked to Bereiter's discussion of inquiry (1992) in which he describes the scientific approach to inquiry as a commitment to:

1. work toward a common understanding satisfactory to all
2. frame questions and propositions in terms of evidence
3. expand the body of valid propositions
4. subject any belief to examination

The issue of sustainability was carefully considered in the design of the courses. The energy and momentum of regular face to face interaction had to be matched with structures and spaces. Capra (1997) has posited that sustainable communities are characterized by information available on demand, feedback loops for individual self-regulation, clearly defined niches or roles, and clear goals. Davis (1997) suggests that these principles for building a community can be translated into the online environment through having clear goals with rubrics to define them, creating challenges that cause relationships to form through the exchanges of ideas, providing regular reflection for individuals and groups, and creating a structure or place that mirrors the key forms of interaction and allows the virtual community to form. This led us to have participants focus on information collection, then enter "virtual space" where they test ideas and ask questions of each other, and of the mentors. Rogers and Laws (1997) also addressed the challenge of building a community through extensive online discussions and providing opportunities for cooperative learning.

Methods, Techniques or Modes of Inquiry

Four sections of participants (middle-school teachers) enrolled in the courses (N=72) over a three-year period. Each section had two mentors, a master teacher and an earth systems scientist. The mentors guided discussions by interjecting when necessary, responding to weekly discussions, and replying to students' journal entries.

The online environment was seen as a place for collaboration and knowledge building, not as a repository for earth systems content. With this view in mind, participants were mailed necessary background reading materials, CD-ROMS, and other supporting materials. The online site was limited to week by week instructions, information about expectations supported by rubrics, a guide for how to thrive in online communities, and the discussion area itself.

Course activities consisted of online collaborative discussions, individual research for information concerning earth systems science, group construction of earth systems diagrams about major earth events, and individual design of new activities for classroom use. Facilitators supported, coached, replied to journal entries, and intervened only to provide administrative instructions, to maintain the course flow and direction, or to address specific earth science content.

Course developers provided participants rubrics as guides for course expectations and grading purposes. Participants were given points for individual and group tasks. Points were also awarded for journal entries and for the final project. For the final, participants could develop an earth systems diagram based on theories about geoengineering, or they could submit an article to Science Activities magazine.

Data Sources or Evidence

A variety of techniques was used to gather information. First, all participants were administered a survey at the beginning of the courses. The survey asked teachers about their prior knowledge about using technology, about earth system science, and about their sense of community. At the end of the course, teachers were administered a comparable survey to get a sense of changes in perspectives about teaching and learning and content knowledge about earth systems science.

Another source of information is the discussion and artifacts of 16 weeks of activity by the teachers in all three courses. The activities were designed to challenge teachers to synthesize the content through discussion, reflection and evaluation. Artifacts include discussions, journals, emails and evaluations of work by peers and mentors.

The course facilitators also completed an end of course survey. Answers to this survey, from the perspective of facilitators emphasized the amount of work, time, and planning that has to be devoted to successful online course execution.

Results and/or Conclusions/point of View

Who succeeded in this course? Seventy-five percent of those who signed on completed the course. One participant noted in an email that she hoped the course would never end. Several reported being surprised at the at how much their thinking improved as they struggled with the content. Some individuals dominated discussion and some shied away, remaining aloof and laconic, much like face to face discussions would be. Rogers and Laws (1997) suggest that students who succeed in asynchronous, distance learning courses tend to be those who are self-disciplined. McClure (cited in Hafner, 1997) in discussing development of the Well, said developers thought the best participants would be intelligent people with diverse backgrounds and who were sufficiently outgoing and extroverted. In these courses, initial engagement in the task and an understanding of the course structure were good predictors of ultimate success.

The courses were extremely rigorous and time consuming for teacher and mentors alike. They were designed to be this way, yet many teachers had not anticipated the heavy workload. Others signed on to learn technology and so struggled to become proficient. Some self-starters were reluctant to ask basic questions and would have dropped out without intervention and scaffolding by the facilitator. This is similar to the negotiations likely to ensue in on-campus, face-to face courses. A combination of public and private communications was critical to providing individual support.

Having a master teacher and an earth system scientist was a luxury that few universities can afford. If this becomes too problematic, course providers could elect to spread the scientist's workload over multiple sections. A frequently asked questions (FAQ) area could also be developed.

Even with two mentors per approximately 20 students, the mentors' workload was significant. Developers would do well to keep the number of students at no more than 24. Based on what was observed in these courses raising the number of students is likely to detract from students' learning.

Developers envisioned all course coordination and discussions being taken care of in the virtual space.

A conscious effort was made on the part of the developers and mentors to use only the virtual space for communications. This proved to be overly optimistic; phone calls and emails were used to provide scaffolding and support. Multiple means of communication are not only likely to occur but necessary in order to overcome the geographic gap inherent in online communities.

Giving teachers weekly tasks and time limits paid off, especially in this asynchronous environment. The best weekly timeframe was Monday morning through Sunday night; teachers liked to have the whole weekend to complete assignments.

The conscious interweaving of implicit and explicit professional development was examined through asking the teachers to reflect on their experiences as learners and its effect on their practice. The majority of the participants were sufficiently impressed with their own level of engagement and increased knowledge and skill to begin moving their own teaching in that direction.

Educational or Scientific Importance of the Study

An overriding objective in the development of these online courses was to create "reasons" for individuals to engage in the material. The population consisted of very busy classroom teachers. Course developers purposely designed the structure so that the course was student-centered and so that participants relied on each other for input. In one of the courses, this was accomplished through the jigsaw strategies that made participants depend on each other for essential information in creating the earth systems diagrams. There is always room for improvement and fine tuning, but these courses' execution has been such that after some minor adjustments, they will offered again and will provide a model for development of other online courses.

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The National Network for Earth Science and Engineering Learning

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Abstract

Earth Science and related Engineering are drivers of resource wealth generation and are core determinants of environmental health. They are often ignored by the young and misunderstood by the community. We are seeing changes in both science literacy and understanding which, if not changed, will have a significant adverse impact on the standard of living and the quality of life of all Australians. This nation is headed in the direction of comfortable upper-middle class non-wealth producing professionalism, forgetting that *"comfort"* needs to be earned. Many concerns for the environment conveniently ignore this relationship. *It is actually quite difficult to be green if one is in the red.* Sustainability has two sides.

Such changes in science literacy and understanding are increasingly obvious in secondary schools where students are turned off hard science, and where many teachers having skills in earth science and related engineering have retired or are close to retirement. These skills are not being replaced, while those teachers who remain are seeking both resources and skills.

The National Network for Earth Science and Engineering Learning (NNESEL) will provide cutting edge information enabling problem based group learning both at hubs in State capital cities and also within remote schools via internet delivery. NNESEL will provide resources and skilled mentors in these disciplines for both teachers and students. In this way Australia will be better prepared to meet its future.

A Multidisciplinary Curriculum in Fossil Biology and its Effect on Student Understanding of the Temporal Nature of Evolution

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There are few concepts in Geology more important than time. Its influence is felt in many disciplines, most notably biology, wherein a massive time scale is a necessary condition for the evolutionary process. Yet, much of the research in science education has ignored the influence of geological time on evolution and has instead concentrated on problems associated with the teaching of Natural Selection. This work intends to redress this neglect.

The learning program, "From Dinosaurs to Darwin" designed by the authors emphasizes the concept of geologic time in evolution in two ways:

1. A large-scale framework (sometimes termed "deep time") in which biotic change occurs.
2. An active logical process used in reconstructing past environments and organisms, based on a series of scientific principles, such as uniformitarianism.

In the first chapters, the problems students encounter are basic, and concrete, such as fossil identification. This provides them with the tools needed for basic fieldwork investigations, wherein the students attempt to decipher the environmental influences that have affected a fossil site through time. By the end of the program, students are able to interpret more abstract phenomena, including life habits of fossil organisms, evolutionary rates, and mass extinction.

Concurrent with the effort in curriculum development is a research program, which has attempted to classify learning difficulties associated with the program and the concept of geological time. As part of this process, the researcher is attempting to build a cognitive model that might better explain how students conceptualize geological time. In the earth sciences, temporal understanding is mediated by a series of scientific principles, which allow one to reconstruct the time-induced changes that take place in both the physical and biological environments. It is suggested however, that such principles might be based on a collection of cognitive skills that we use in order to orient ourselves to temporal phenomena on a day to day basis. In the psychological literature such cognitive skills largely fall under the category of "causal reasoning". Bullock, Gellman and Baillaregeon (1982) define causal reasoning as the ability to group temporarily successive occurrences into coherent units based on cause-effect relationships.

Cause-effect relationships can be broken down into the following cognitive skills:

1. Establishing priority: This involves determining the temporal ordering of cause-effect events on the basis of physical clues interpreted from one's surroundings. In geology priority is established through principles such as superposition and correlation.
2. Determining mechanisms: This involves searching for antecedents that might have produced the phenomenon. In geo-biology, this skill is equivalent to the principle of uniformitarianism, which builds connections between present and past events by a commonality in structure.
3. Determinism: This involves determining the causes of an event. It is strongly correlated with knowledge.

An assessment test was designed to test the cognitive skills involved in causal reasoning. This open questionnaire was divided into two sections: the first consisted of a series of puzzles which tested students understanding of geo-biological phenomena; the second consisted of a "detective story" which tested their ability to transfer the skills learned in the program to areas outside of geology and biology. This questionnaire was distributed both before and after implementation of "From Dinosaurs to Darwin" amongst a research population consisting of two grade 9 classes (60 students in total) and one grade 12 class (25 students in total).

Results from the first implementation cycle indicated that students significantly improved their ability in establishing priority using geological principles such as superposition and correlation. It is interesting to note that Ault (1981, 1982) found that even very young children (K-6) were able to solve problems of these types. However, it must be noted that the questions used in this study were more complicated. Moreover, the subjects in this study were also able to solve such problems in the field unlike Ault's (1981, 1982) subjects who had great difficulties applying their temporal understanding to the field.

Students had greater difficulty answering questions requiring an understanding of uniformity, in part because such thinking involved knowledge that they may not have assimilated. Moreover, uniformitarianism subsumes the skills noted above making them more complicated to understand. Nonetheless, there was still significant improvement in this section of the questionnaire after learning the program.

In the transfer level questions (from the "detective story"), the students showed improvement in most test questions, although it was not significant. The greatest difficulty involved questions that required approximations. For example, when asked to provide a time for an event's occurrence, the students emphasized a specific hour rather than a time range.

An analysis of the cognitive assessment test indicated that certain factors appeared to interfere with the students' ability to solve the geo-biological puzzles. One of the most prominent factors appeared to be the ability to understand three-dimensional structure. This assumption makes sense if one considers that in order to reconstruct the formation of geological structures one must first understand its spatial structure. To test this hypothesis, a population of 65 students was tested with both the cognitive assessment test and a validated test of three-dimensional thinking. Correlation of these two tests ($R = 0.42$) indeed supports the hypothesis that temporal understanding is indeed influenced by spatial thinking ability. It is interesting to note that this result correlates well with Friedman's (1982, 1990) research that from age 12 children mentally organize conventional time frameworks (for example, days of the week) in a spatial pattern.

A second questionnaire was designed to test students' knowledge of evolution, as well as the scale and absolute size of geological time. After implementation, the students showed improvement in describing evolutionary transitions (such as why skeletons evolved amongst animals). More difficult was providing the proper scale for evolutionary events. Although students could often provide the absolute age of an event after learning the program, they sometimes lacked perspective of the place of such events in geological time. This lack of correlation between absolute age and scale indicates that for students long expanses of time remain an abstraction that might be remembered simply as information (in this case numbers), but with little significance to evolutionary events.

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Bringing Planetary Science down to Earth - Transforming the 62nd Annual Meeting of the Meteoritical Society into a learning experience for the general public.

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Introduction

The Meteoritical Society has over the years fostered interest and promoted research into many aspects of planetary science, in particular the study of extraterrestrial materials including meteorites, lunar rocks and cosmic dust, and meteorite impact studies. The Society's Annual Meeting attracts top scientists and researchers from around the world to deliver their state-of-the-art presentations on current projects in the technical sessions. Traditionally, the scientific sessions have been highly specialized and have appealed to a limited number of non-specialists and a small number of physicists, chemists, astronomers, earth, and life scientists.

The 62nd Annual Meeting of the Meteoritical Society - METSOC '99 - held at the University of the Witwatersrand (WITS), Johannesburg, South Africa, represents the first such meeting on the African continent, and only the second in the southern hemisphere (after the 1990 meeting in Perth, Australia). The 1999 conference was organized by the WITS Impact Cratering Research Group - the only such group in the southern hemisphere - and members of the Department of Geology, together with staff from the Council for Geoscience and the National Cultural History Museum (both in Pretoria), as well as a member of the Astronomical Society of South Africa. Their efforts were, inter alia, supported by the South African Department of Arts, Culture, Science and Technology and the Foundation for Research Development (part of the National Research Foundation).

Central to the WITS bid for the 1999 Annual Meeting was the need to, on the one hand, further the interests of the Meteoritical Society in a continent where members to date have been a rarity and, on the other hand, to make effective use of the scientific and analytical expertise epitomizing the membership of the Meteoritical Society to the benefit of science in Africa and, particularly, southern Africa. This was recognized by the Society which decided to provide sponsorship specifically for the meeting and embraced the Organizers' ideas of making METSOC '99 an event with a difference. This meeting was designed to attract participants from less developed parts of Africa and to involve the general public more than at previous meetings. The outcomes of this public programme will be reported on.

Transforming the 62nd Annual Meeting of the Meteoritical Society.

The organizers designed a regular technical program for conference delegates as well as a public program. This public program includes a National Lecture Tour appealing to the general public and presented by "volunteer" members of the Society, sponsorship of deserving young scientists, the launch of Volume 1 of the "Popular Geology Series" of the Council for Geoscience, a book aimed at the lay person, as well as involving international conference delegates in the plans around the Tswaing Crater Museum and Education Centre.

National Lecture Tour

Impact cratering is a geological process that is often not appreciated despite the fact that it is the most important surface-modifying process on all planets and satellites with solid surfaces in the Solar System. Impact cratering also influenced the geological and biological evolution of our own planet in the past and is likely to do so again in the future. It is now commonly accepted that an enormous impact event occurred some 65 million years ago causing the extinction of the dinosaurs and a vast number of other life forms. There is a 1 in 10 000 chance that a large asteroid or comet greater than 2km in diameter may collide with the Earth during the next century, severely disrupting the ecosphere and killing a significant percentage of the earth's population. The impact of much smaller bodies occurs more frequently but can be just as devastating. An iron or stony meteorite 250m in diameter possesses the kinetic energy equivalent to about 1 000 megatons of TNT and would produce a crater about 5km in diameter. Such impacts, which occur on Earth about once every 1 000 years, would destroy about 10 000 km^2 and locally disrupt human civilization. An understanding of impact structures and the processes that give rise to them should, therefore, be of interest not only to earth scientists, but also to the general public.

Volunteer members of the Society will present a series of general interest lectures at historically underprivileged university campuses and some smaller towns in all regions of South Africa and into Botswana. This lecture tour was made possible through generous sponsorship by the International Planetary Society, the Mineralogical Association of South Africa, Anglogold (Pty) Ltd and the government agencies mentioned above. All the public lectures have been widely advertised and admission is free to ensure that no-one would be excluded from participating in this learning experience.

The aim of this lecture series is to introduce the general South African public to the origin and nature of meteorite impact processes, and what meteorites can tell us about the Solar System. The lectures will be illustrated with many examples from around the world as well as South African examples. It is believed that this will make the general public more aware of our own natural heritage in the form of the Tswaing Crater and the Vredefort Dome, and will hopefully stimulate interest in physical science education.

Sponsorship of deserving young scientists.

A number of Travel Grants were made available by the Meteoritical Society and by the Barringer Crater Company to enable deserving young scientists from African and other southern hemisphere countries, as well as other underprivileged scientists to attend METSOC '99. By attending this meeting selected students will be afforded the opportunity of mixing with meteorite specialists of international standing and of being exposed to state-of-the-art research by scientists coming mainly from the privileged northern hemisphere countries. These students would not have enjoyed this cross-fertilization and learning experience, except for receiving these travel grants.

"Popular Geology Series"

The "Popular Geology Series" is an initiative by the Council for Geoscience to popularize local geology and to promote the earth sciences. The launch of Volume 1, "The Tswaing Crater - a Natural and Cultural History of the Tswaing Region", has been planned to coincide with METSOC '99. This multi-disciplinary book is aimed at the lay person. It provides a general background on meteorites and meteorite impact structures, but focuses on the geology of the Tswaing meteorite structure in particular. It also covers the fauna and flora of the region and serves as a guide to the crater hiking trail. The book provides a review of the sociopolitical development of this region during a period of South African history when the majority of the people inhabiting the area were severely affected by the laws of the time.

Tswaing Crater Museum.

Tswaing is a 2000-hectare site, some 40 km north-west of Pretoria, surrounded by settlements inhabited by more than a million people. The main features of this site are the 200 000-year old meteorite impact crater, a marsh area, a variety of ecosystems, and the remains of a factory that produced soda-ash and salt during the early part of this century. In geological terms, the Tswaing Crater represents one of the youngest and best preserved small, bowl-shaped, meteorite impact craters in the world. The crater is known internationally as the Pretoria Saltpan. Tswaing means "place of salt" in the Tswana language.

Since 1993, Tswaing has been developed by the Museum of Cultural History as a museum in partnership with local communities, universities and research institutions. Strong emphasis is placed on the protection and use of the area's natural and cultural heritage for research, education and recreation. The 7 km long Tswaing Crater Trail is a walking trail that gives visitors a first-hand experience of the crater and surroundings. Places of interest along the trail are interpreted through signs. As a green island surrounded by largely informally urbanized settlements, Tswaing is a significant environmental education resource for the hundreds of schools in the immediate region. Sponsored by a major gold-mining company (Goldfields of South Africa), some ten outdoor classrooms have been established along the trail where environmental education programmes are presented. In addition to this, an environmental education centre, including accommodation facilities, has been completed from the same sponsorship. Educational programmes are presented by the Museum's Education Officer and by trained guides from the local community. A temporary exhibition on Tswaing completes the education picture. Plans are currently underway for the development of a proper museum building which will house permanent planetary science exhibitions, as well as information regarding the local and regional geology which provides - through the intensive mining activities of the Bushveld Complex - the livelihoods of many people living in this part of South Africa

A mid-week field trip by METSOC '99 delegates to this site will expose the international community of meteorite and impact specialists to the education centre, and their comments will be noted for future planning in an attempt to enhance the work-in-progress at this valuable, natural resource, and thereby benefit the general public and the thousands of pupils who visit the site annually.

The Use of the Web in the Teaching of the Geosciences at Australian Universities

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In Australia, as yet only a small number of academics have got past the initial stage of simply "putting up" lecture notes and class handouts on a web page. In fact, many schools and departments of geography and geology make *no* use of the web in their teaching. It is useful to classify the possible utilisation of the web in mainline university teaching into six categories.

The teacher as a client

Many web sites are specifically designed to be a repository of information about, and sometimes suppliers of, teaching materials. These sites are designed to be used by *teachers*, not students.

The site maintained by UniServe Science (http://science.uniserve.edu.au/) is an example of such a web site. The site contains: articles related to the use of information technology in university science teaching including both geography and geology; details and reviews of relevant software; mirror sites for the downloading of appropriate software (e.g. Teaching and Learning Technology Programme (TLTP) GeographyCal); and useful links. UniServe Science also hosts email discussion groups in both geography and geology.

The student as client: Informal use

The simplest way in which academics can make use of the web in their teaching is to supplement their normal teaching by simply "putting up" their teaching materials, lecture notes, PowerPoint presentations, course handouts and schedules on the web for students to consult if they want to. In time these can develop into a very rich collection of teaching materials. Some local examples of this informal use of the web and the valuable resource being developed can be found at:

- Geol 1002: Earth Science Evolution of the Earth and its systems, ANU (http://gemoc.anu.edu.au/course/geol1002/index.html);
- An Introduction to Physical Oceanography (Flinders University) (http://www.es.flinders.edu.au/~mattom/IntroOc/newstart.html); and
- GEOS239 Remote Sensing of the Environment (University of Wollongong) (http://www.uow.edu.au/science/geosciences/ugrad/subjects/GEOS239.htm).

Web resources which make use of features such as immediacy of information, colour and animation, and platform independence provide useful supplementary material for the teaching of the geosciences. These include:

- up-to-date source of information particularly relating to earthquakes and volcanoes;
- petrological resources such as the Rock Sections Browser at The University of Tasmania (http://www.geol.utas.edu.au/codes/pracs/rock.htm);
- virtual field trips; and
- applets such as Learning with JAVA Applets from Geophysics Department TU Clausthal (http://www.ifg.tu-clausthal.de/java/Welcome-e.html).

The student as client: Formal teaching via the web (1) delivery of material to be learned

A step beyond the last category is where the web is used as the prime means by which the course (or some parts of the course) is taught. Here there is some sort of compulsion for the students to consult the web. The Department of Earth and Planetary Sciences at Macquarie University is conducting complete programmes via the web.

The student as client: Formal teaching via the web (2) student/teacher interaction

There are many programmes now available that allow for interaction between teacher and student with either synchronous or asynchronous communication via web features such as email, discussion groups, chat rooms. Rob Mclaughlan at UTS teaches a subject (Contaminated Sites Management) predominantly over the web; with course announcements, student assignment sharing, on-line self and peer assessment, and a F2F/email/chat.

The student as client: Formal teaching via the web (3) formative assessment and feedback

This is an area where much more work has been done. It combines the three main advantages that the web has to offer: flexible access; immediate feedback; and platform independence. A web-based assessment tool, WebMCQ (http://www.webmcq.com/) was developed by James Dalziel at The University of Sydney and is being used by Tom Hubble in the School of

Geosciences at the same university to conduct an Internet based trial examination.

The student as client: Formal teaching via the web (4) summative assessment examinations
To our knowledge, no geoscience department in Australia is conducting all final assessment for a whole course through the web, mainly because of the inflexibility of question format and security issues.

Two issues which face Geoscientists as they embrace the web as a vehicle for teaching are:

- that the pedagogical issues of the delivery of teaching materials and assessment of student performance via the web, remain a priority; and
- cooperation between universities especially in the development of web-based courses that could be shared be encouraged and so be made more cost effective.

Potential for Earth Systems Education in Cyprus

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Cyprus is the third largest island in the Mediterranean Sea. It is an exceptionally rich area geologically, and has a variety of ecosystems from high mountain forest to fertile agricultural lands to true desert. The 771,000 inhabitants of the island are divided by a political boundary that separates the Greek Cypriots of the Republic of Cyprus from the Turkish Cypriots. This research was conducted among secondary science teachers in the Republic in winter 1999. At that time, there was no Earth science course offered in the national curriculum, but most physical science aspects of Earth were taught as geography. There was also no formal environmental education in the curriculum at any grade level.

The purpose of the research was to establish a baseline characterizing the teachers' interest in and readiness for Earth and environmental education. It is hoped that the interest raised about this curriculum innovation will stimulate action for positive educational change.

Earth Systems Education

According to a growing number of scientists and educators, the appropriate focus for all of science in the curriculum is Earth, with its interacting components of water, land, air and life, and with its instant relevance and interest for students (Fortner and Mayer, 1998). Earth systems education emphasizes the interdisciplinary aspects not only within science but of science with the other subjects of the curriculum as well. It is taught through student investigations driven by interesting questions to be explored, so the sciences are learned on a need-to-know basis rather than as chapters in a given order in an encyclopedic textbook. It fosters appreciation of Earth's beauty and value, which rarely happens in traditional science classrooms.

Many of the questions investigated in Earth systems education relate to environmental issues and how human beings use the resources of the planet. Not only do such studies offer rich experiences with real data, and the need to consult many disciplines in search of answers, but they also provide a reason for doing science and a means of introducing the value of good stewardship of resources.

The key elements of Earth systems education are contained in a simple Framework of Understandings developed by scientists, science educators, and classroom teachers (Mayer 1995). These elements are also the basis of what many feel is important in global science literacy as well as much of what is traditionally considered the realm of environmental education. The scientific thinking and decision-making aspects of Earth systems education are appropriate bases for approaching environmental issues rationally.

Framework of Understandings for
Earth Systems Education

1. Earth is unique, a planet of rare beauty and great value.
2. Human activities, collective and individual, conscious and inadvertent, affect Earth systems.
3. The development of scientific thinking and technology increases our ability to understand and utilize Earth and space.
4. The Earth system is composed of the interacting subsystems of water, land, ice, air and life.
5. Earth is more than 4 billion years old, and its subsystems are continually evolving.
6. Earth is a small subsystem of a Solar system within the vast and ancient universe.
7. There are many people with careers and interests that involve study of Earth's origin, processes, and evolution.

If innovation is to come to Cyprus and other regions in the form of new Earth systems subject matter or integration of existing subjects around environmental topics, research such as this would provide a preliminary measure of how relevant such innovation might be, and how prepared teachers are for implementing it.

Research Methods

Questions guiding this study were:

5. What priority do teachers place on certain Earth systems and environmental topics for students in their schools to know?
6. How do teachers assess their own knowledge levels about these topics?
7. To what extent are teachers currently teaching the topics?
8. What relationships exist among teachers' priority ratings of topics, their knowledge, and current levels of teaching them?
9. In what forms do teachers prefer to receive information and curriculum materials?

A questionnaire was distributed to secondary science teachers at a required briefing held by the Ministry of Education and Culture. The survey listed 12 environmental issues identified by a focus group of Cyprus teachers, and another ten topics representing Earth systems content that curricula might include. For each of the 22 topics, teachers were asked

4. How important is it for students in your school to know about the topic?
5. How much do you know about the topic?
6. To what extent are you currently teaching it?

For each question, teachers circled a level of response from 1-4, with 4 representing the highest degree of involvement. For those topics with the lowest level of teaching indicated, teachers were invited to supply reasons for not teaching them.

The survey allowed teachers to express their preference of information sources for themselves and instructional materials for use with their students. They also identified the format of inservice education that was most appropriate for them.

A total of 110 useable responses were returned from the population of 167 natural science teachers, for a response rate of 61%. The respondents included 53 males and 44 females, with an average of 18 years' teaching experience. All were teaching in public schools and 90% were from the cities rather than villages of Cyprus.

Results

Responses to Questions 1-3 are summarized in Figure 1 for environmental issues and Figure 2 for Earth systems topics.

Figure 1. Teacher Priorities, Knowledge and Teaching of Environmental Topics

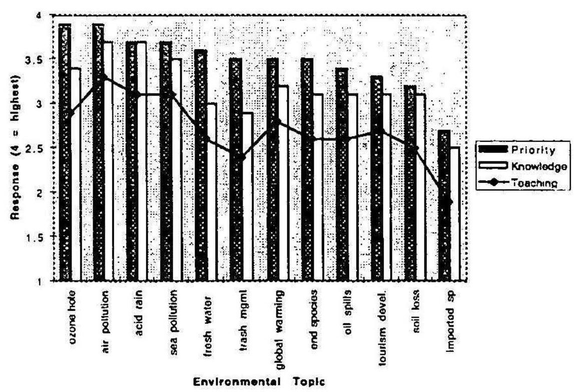
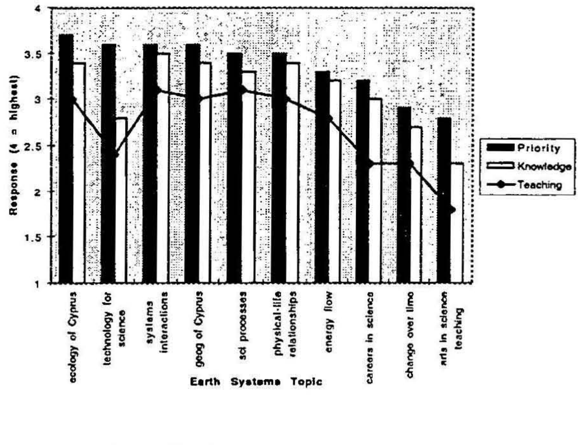


Figure 2. Teacher Priority, Knowledge and Teaching of Earth Systems Topics



Teachers found all the environmental topics important for their students (average rating of 3, with 4 being the maximum possible) except imported species. The highest priority issues were ozone hole, air pollution, acid rain, sea pollution and trash management. For Earth systems topics the most priority was given to ecology and geography of Cyprus, along with technologies for science and systems interactions. Those rated lowest were change over time and arts in science teaching.

The knowledge teachers reported having for the topics was lower than the priority rating in every case except for the topic of acid rain, which was equal to priority. Teachers reported knowing most about air pollution, acid rain and sea pollution. Lowest knowledge levels were reported for fresh water availability (mean 3.0 of 4), trash management (2.9) and imported species (2.5). For Earth systems topics teacher knowledge was lowest in technology for sciences (2.8), change over time (2.7) and arts in science teaching (2.3).

As for teaching about the topics, most teachers reported they "introduce" the topics (response level 2), and for a few topics offer "moderate teaching" at level 3. In this instance, more Earth systems topics than environmental issues are being used at moderate levels in the classroom. Environmental topics with means greater than 3 (moderate teaching) are air pollution, acid rain and sea pollution, along with Earth systems topics of systems interactions, science processes, geography of Cyprus, and relationships between physical and life sciences.

In answer to Question 4, relationships among priority, knowledge and teaching were all positive and significant ($p<.05$). There are discrepancies, however (defined simply as the numerical difference between the means, P - K or K - T), between priority and knowledge, and between knowledge and teaching. The greatest discrepancies between priority and teaching were for environmental topics of trash management and freshwater availability (0.6 each), and Earth systems topics of technology for science (0.8 points), and arts in science teaching (0.5). As for discrepancies between knowledge level and teaching, the greatest are in topics of careers in science (0.7) and issues of acid rain, soil loss, and imported species (0.6 each).

For Question 5, teachers selected their primary information sources about the environment from a list of possible media and experiences. The most used media were specialty magazines, books and television (Figure 3). They preferred inservice formats that would yield university credit (Figure 4), and indicated they would be most likely to use instructional materials that were in the form of audiovisual aids or text/reference materials (Table 1).

Figure 3. Information sources used by science teachers

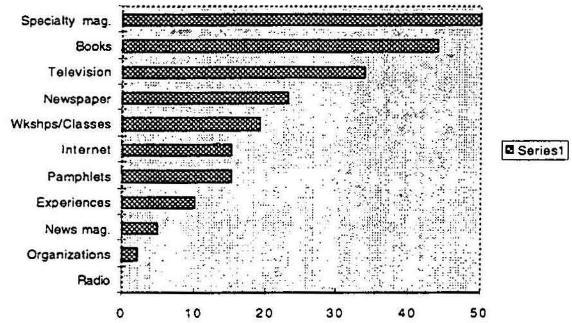


Figure 4. Inservice formats preferred by teachers

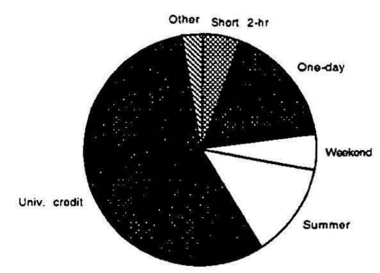


Table 1. Teachers' rankings of instructional materials formats they prefer (1 = highest rank)

Type of material	Avg rank (1=highest)
Audiovisual aids	1.65
Text/Reference material	2.30
Activities/Lesson plans	2.45
Pamphlets	3.26
Teaching units	3.79
Other	4.38

Conclusions

Teachers generally place lower priority on the subject matter that would specifically address Earth Systems Understandings #1 (represented by arts in science teaching), #5 (change over time), #6 (energy flow), and #7 (careers in science). Their reported

knowledge level and amount of teaching in these topics is also considerably lower than other Earth system topics. In addition, they are teaching very little related to the technologies used to study science (a component of ESU #3). Thus the current state is that a high priority is placed only on
environmental topics (ESU #2)
1. interactions of Earth systems and the relationship between physical and life sciences (ESU #4) and
2. the processes of science (ESU #3).

Thus if Earth Systems Education were to become a new curriculum focus, substantive philosophical groundwork would have to be laid, and extensive teacher preparation programs implemented to equip teachers with the interdisciplinary subject matter and methods for instruction.

Teachers indicated that for those topics they were teaching least, there were numerous reasons for excluding them from the curriculum. The primary reason given was that the teachers believed the topics were not among their responsibilities. Some specified the topic belonged at another level or in another discipline. For some topics they indicated they did not have enough time or appropriate teaching materials, or the topic was not an issue in Cyprus (whether this meant it was not a curriculum issue or not a subject issue was unclear).

Numerous issues arise from this analysis. First, some critical subject matter is not reaching students in Cyprus. Imported species are common on the island, and though some are showing obvious negative impacts there is no agricultural inspection at Customs, and people routinely bring favorite plants from other countries for cultivation in Cyprus.

Fresh water availability is a serious issue for the country. Water for homes is rationed, with a typical scenario of 12-15 hours of water per day, three days per week in every season except winter when sparse rainfall comes. What is not taught about water appears to be the concept of consumptive versus nonconsumptive uses. Agriculture claims 78% of the island's water use, and the popular citrus and peanuts (non-native crops) are the biggest consumers. Combining the science of hydrological processes with the social applications of water would provide excellent instructional opportunities for data analysis and decision-making. Since water management in Cyprus relies on reservoirs, desalination, and some recycling of waste water, incorporation of these technologies into discussions in science classes would help to address the deficiencies in ESU #3.

Before these curriculum changes can be implemented, it is clear that teachers must have additional education. Most have only Bachelor's degrees with which some have been teaching for over 30 years (average 18). They indicate that courses for university credit would be most desirable for inservice, and this should be taken as a mandate for Cyprus' higher education institutions. Interdisciplinary, perhaps interdepartmental graduate courses for teachers would find a ready audience, and the secondary science education program could be considerably enriched by the effort. Not only science updates, but immersion in current pedagogical thinking and practice are needed to overcome reliance on the lecture-test mode of instruction. Thus there is great opportunity but also great challenge for the educational systems as it enters the millennium. An emphasis on Earth and its environmental concerns would be an enriching path for Cyprus' future.

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Museums, geology and scientific literacy - the radon issue as an example

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Recent official reports in several countries (AAM, 1992; NOU 1996; SOU 1994) outline new goals for museums, involving a role for museums as public service institutions, meeting places, arenas of public debate, dialogue institutions and contributors to the resolution of global challenges.

We interpret these new goals to be very much in line with the efforts to promote scientific literacy. Can museums fulfill such a function in society? We suggest that if museums are to contribute to the public's scientific literacy, the following conditions must be met:

1. **Perceived need for information**: The audience must feel a need for information enabling them to deal with science-related issues in their private or civic lives
2. **Museums as sources of information:** The audience must perceive museums as relevant sources of such information
3. **Relevant topics:** The museums must in fact offer information on the relevant topics
4. **Form of communication:** The museums must offer the information in a form which the audience understands and is able to apply to the civic or private science-related topics of interest
5. **Accessibility:** The museums must be practically accessible; that is: they must be open at times when the audience finds it convenient to visit; they must not be too expensive, they must offer parking space etc.

The main aim of this study was to investigate museums' potential of fulfilling the new goals. As an example we chose a science-related issue that citizens may encounter in their private or professional lives, namely the issue of radon in homes or workplaces. In this study, we wanted to explore the potential of museums to provide information and experiences that the audience finds relevant for dealing with the radon issue. More precisely, we wanted to throw light upon the following questions:

1. How do people react when confronted with a science-related issue such as the radon issue? Do they feel a need to get a grip on the scientific aspects of the issue, and if so, what sources of information do they regard as relevant?
2. Do people see museums as institutions that can provide information that empowers them to deal with science-related issues in their own lives?
3. How does the audience look upon the role and aims of museums, and how does this view relate to the new aims stated for museums in official reports?
4. How do museum professionals look upon the role and aims of museums in supporting public scientific literacy?
5. Do museum professionals perceive their own museums as fulfilling the functions described in official museum reports? If so, how? If not, what are the major obstacles?

We have performed focus group interviews with parents whose children went to a school where high concentrations of radon gas had been detected. To find out if parents perceived museums as possible sources of information concerning the radon issue, we invited them to visit two science and natural history museums in the Oslo region, one of them a traditional natural history museum; the other one of the more modern, technical museum in Norway.

We found that our group of parents did *not* see the two museums in Oslo as providing experiences and information relevant for dealing with the radon issue; neither did the parents expect museums to have such a role. (Museum professionals from the two museums expressed similar attitudes.)

Rather than concluding that the new goals for museums should be abandoned, we suggest that museums must reconsider their priorities in order to approach the new goals. Based on our findings, we suggest a few ways in which this may be done.

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Natural Disasters in Japan From The Viewpoint Of STS (Science -Technology - Society) Education

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Issues and Purpose of The Study

Standing on a volcanic belt with four plates pushing each other, Japan has always been exposed to fear of earthquakes. Active diastrophism caused the steep-sloping shape of its mountains which make up 70% of its land surface. Meteorologically, Japan's precipitation is high because it is located in a temperate monsoon region. These features have been the cause of several kinds of natural disasters in Japan where many people live in a small land.

After rice farming was introduced from China, flooding became a serious problem for people who were living on an alluvial plain formed by rivers. As centers of population grew on the soft ground, urbanization brought increased danger of natural disaster. Faced with limited width of land, people needed to use land effectively, and also learned how to prevent or minimize the impact of natural disasters using science and technology. Natural disasters are interwoven with social factors and are often inextricably linked to the consequences of social decisions. These natural and social conditions mutually expand the range and impact of natural disasters and their possibility. This is why an STS (Science - Technology -Society) approach is needed to understand and analyze natural disasters and to prevent them.

In Japan, as a consequence the Hyogoken-nanbu (Kobe) earthquake 1995, the proposed course of study calls for a more integrated approach to the teaching and learning of science. In this article, the authors argue that an STS focus is well placed to provide a theoretically sound and effective approach to integration. If one of the main objectives of science education is to provide a solid basis of scientific literacy for a country's citizens, then approaches to teaching science need to recognize that science, technology and society are intimately related.

Nowhere are these differences more evident than in how science education deals with natural disasters. The authors take the view that geoscience education has an essential role in describing the causes of natural disasters, in their prediction, in prevention, or at least in the minimization of damage caused by such events. Geoscience education has a fundamental role in developing a knowledge and understanding of the scientific principles underlying the causes of phenomena resulting in natural disasters. The authors argue that an STS approach needs a rigorous conceptual and theoretical development. The study of natural disasters, or selected instances of such disasters, provides a sound basis for science education and for scientific literacy.

General Appearance of Contents Related to Natural Disasters

Given the impact of flooding and earthquakes in Japan's history, it is not surprising that there are many more references to natural disasters in school science education. Content in earth science related to natural disasters is included in elementary and lower secondary curriculum which all students take generally. However, only a small number of upper secondary students learn earth science because of the optional course system. Earth science in the upper secondary level was introduced after World War II as a minor subject with relatively few specialized teachers compared to mainstream science subjects such as Chemistry and Biology. As a result, only a small number of students learn earth science and take it in their entrance examination of universities.

In general science courses, we note very limited knowledge related to earthquakes. Although the attitude of Japanese toward nature may be well informed, any serious treatment of natural disasters needs to take account of the wide variety of natural environment for each region as well as localized natural disasters. Perhaps, one reason why natural disaster has not been taught is that Japan's educational policy has neglected these diversities through its standardized Course of Study.

Certainly, in the past decade, environmental education has attracted a great deal of public attention. One of the feature of environmental issues is that many were due to over approaches or unthinking work by human being as the cause of natural disaster. They are metamorphic issues. Any teaching about the impact or prevention of natural disasters has to confront entrenched positions about what constitutes scientific knowledge and what belongs elsewhere in the curriculum. To what extent, for example, should the science curriculum deal with disaster prevention and human intervention. Any inclusion of these features will require a more integrated approach to the teaching of science; and therefore deciding what is 'within' natural science and what is 'out of' natural science (Otsuji & Tsuruoka 1994).

Some school activities do relate to disaster prevention, such as emergency drill and volunteer activity. Also schools play an important part as places of refuge for the community in time of disaster

(Nishimura et al 1998). We see a need to establish natural disaster education in science education with relation to other subjects and these activities.

Here, we use the Hyogoken-nanbu Earthquake 1995 as focus point or lens through which to examine some key issues relating to the study of earth science. Kobe, one of the largest modern cities in Japan, was devastated in 1995, a disaster which attracted world wide attention and relief effort.

As a consequence of this event, there has been a renewed effort at preventing such disasters in Japan. Since the great Kanto earthquake earlier this century, Japan now has vastly more sophisticated technology for detecting early signs of earthquake activity, and highly sophisticated information technology for bringing such information together, and for coordinating emergency services.

The Kobe disaster of 1995 can be considered as a defining event which allows us to ask key questions about the adequacy of Japan's current and proposed science curriculum. To prevent and to reduce danger of such disasters, a high scientific literacy of Japan's citizens must be promoted.

Relation Between STS Education and Education Concerning Natural Disasters

Only quite recently has discussion of Science-Technology-Society Education been introduced in Japan. In the field of Earth Science, few attempts have so far been made at STS Education in spite of the rich possibility which this subject presents. Now, we would like to emphasize the practical examples concerning natural disasters in STS teaching materials or program.

Fujioka (1996) indicated the changes of the students consciousness in one year after Hyogoken-nanbu Earthquake. When the earthquake occurred, the students appeared most interested in the scale of the earthquake. But after three months, students were less interested, and appeared to lose interest altogether after just one year. Three months after the earthquake, students began to be interested in emergency housing, the response of administration, and the damage to and restoration of highways and railways. But items concerning science, for examples, fault lines and the geology of the damaged area appeared to be less interesting for the students.

From this result, it is not too far from the truth to say that students appeared to be more interested in the response to the disaster than its relation to their science program. Important opportunities to strengthen students' scientific knowledge appeared to be lost in failing to make these links. An STS approach makes these links a central feature of effective science education.

Teaching materials about flood disasters have been connected to traditional teaching about river. In discussing teaching materials linking flood disasters to an STS approach, Fujioka (1999) concluded that there were opportunities for students to learn about river improvement and to discuss specific recommendations for improvement after completing this program. It is regrettable that in urban areas flood prevention is the only aspect of rivers that is seen as important for an STS approach, to the neglect of issues relating to environmental degradation of rivers and the need to plan for their improvement.

Those examples show the importance of teaching about natural disasters, from the viewpoint of STS Education. In traditional science education in Japan, it is difficult to teach the relation between nature and human being, even if the phenomenon which bring about disasters and environmental degradation can be treated. Consideration of the technology useful for effecting such treatment or considering the cost of leaving degradation untreated are seen by some to "outside science", that is, as issues better left to other areas of the curriculum. If they are left to other areas of the school program, for example to social studies, many rich opportunities for considering the issues from a scientific and technological perspective will be lost. This is especially important for the new course of study for upper secondary level. For integrating natural disasters into science program, introducing STS Education have great significance, in the means of treating the context of "science" and showing students how scientific knowledge can applied to contemporary issues.

Rapid modernization of Japan's cities appear to have reduced students' consciousness of dangers relating to river flooding. A typical example appeared in the IEA's Third International Mathematics and Science Study (TIMSS), where many students appeared to endorse the importance of river environment, but did not connect rivers with the danger of flooding (National Institute for Educational Research, 1996, 1997).

In Japan, some of the newest and most sophisticated technology has been introduced to assist in flood prevention. Students need to know about these important applications of scientific knowledge. Nature has two faces, plus and minus for people living in Japan. We need to come to a better understanding of both faces and how human agency can be used to minimize danger as well as to promote pleasure and benefit.

Having discussed ways in which an STS approach can be used in the science curriculum, the next problem is how to locate and implement integrated learning into school curriculum. In the new course of study, "zest for living" is stressed. In the proposed national curriculum standards, a subject called "Period for Integrated Study" is to be newly constructed from the elementary school to upper secondary school. In these courses, students can study integrated subject, for instance, international recognition, environment, information, welfare and health. But few teaching materials are yet developed for these lessons so far. In our view, there is an urgent need to include science into this field of cross disciplinary study.

Conclusion

This paper discussed the importance of natural disasters as a focus area in earth science education and for teaching materials in Japan. There is at present only a minor and limited use of this theme in the Japan course of study. Inclusion of this focus, supported by a strong STS approach, would allow Japan to be in advance of the world in linking natural phenomena and social conditions.

In the science program, it is important to develop these teaching materials from the view point of STS Education. Such an approach needs to proceed from a rigorous scientific perspective. Its goal is to have students understand that science knowledge and activity is never "context free", nor is it ever "value free". As such, it provides essential connections for students in the elementary and secondary to make between their learning program in school and their life experience, present and future.

In the new course of study notified after Hyougoken-nanbu Earthquake, it is not surprising to see a renewed stress on natural disasters. But, at the same time, there appears to be a reduction in related the scientific knowledge needed to achieve a scientific understanding of these events, their prevention or minimization of their effects. Current school education provides few opportunities to consider science or other schools subjects from the viewpoint of integration. Trying to anticipate what could be expected in next national curriculum standards are not easy. But two of its goals must be to lift significantly the level of scientific literacy of Japan's future citizens; and also to demonstrate the increasing complexity of relationships between science, applications of technology, and social purposes to those who intend to specialize in the science. Good science education must always take on both challenges.

The next problem is to consider how to train tomorrow's teachers who will take charge of these lessons.

Incorporating a GIS into the SPaRCE Program to Encourage Student Analysis of Earth Science Data

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The Schools of the Pacific Rainfall Climate Project (SPaRCE) is a cooperative field experiment that involves numerous elementary, middle and high schools from various Pacific islands, atolls, and the U.S. The program provides environmental education and curriculum enhancement, and in turn the students collect important environmental data which is being used by scientists all over the world. A recent enhancement of the SPaRCE program has been implementing various technologies to help students develop the knowledge and techniques required to make practical use of earth science-related data. An example of technology successfully incorporated into the SPaRCE program is automated weather stations. Using laptops provided by SPaRCE, students are able to graphically see trends and changes in data.

Beginning the summer of 1999, the SPaRCE program is expanding to include Geographical Information System (GIS)-related computer technologies and to incorporate additional environmental data for earth system science analysis by the students at SPaRCE schools. Initially this program will be orientated primarily towards Hawai'i schools due to the abundance of data available for that region and because many students there have access to both a computer and the Internet. GIS technology integrates traditional database operations, such as attribute queries, as well as statistical analysis with the unique visualization benefits offered by maps. These abilities distinguish GIS from other information systems and make it a valuable tool to scientists and students in spatially analyzing relationships between earth system science phenomenon.

A few years ago, the SPaRCE program supplied a small network of schools in Hawai'i with Cole Parmer pHTestr 3 hand held pH meters. These instruments were used to measure the pH value of rainfall that was collected in SPaRCE rain gauges collected by the students. A handbook explaining acid rainfall and how to operate the meter was also provided to the schools. SPaRCE scientists encouraged the students to collect the pH data and keep a long-term record of their results so that they may perform their own analysis and see simple trends in the data.

Many Hawaiian schools currently collect acid rainfall readings. One school, Kahakai Elementary School in Kailua-Kona, Hawai'i Island, collected rainfall pH values for a period between August 1998 to mid-January 1999. They also performed acid rain experiments using local plants so that they could see hands-on how the acidic rainfall affected the plant's growth and health (Figures 1 and 2). The students also posted their results on their school's web page (Figure 3). This is a wonderful first step for sharing data and results with other students. With the implementation of GIS into the SPaRCE program, SPaRCE scientists hope to disseminate the data to more schools and better allow spatial analysis of the data. An example would be placing the pH data into a GIS format so students could see how the pH values varied between the schools, and by combining with other earth science related data (elevation and rainfall) to determine the causes of the variations.

ESRI recently developed a free, lightweight data explorer (ArcExplorer) that may be downloaded from their Internet web site (Figure 4). The SPaRCE scientists are creating CDs that contain the ArcExplorer program along with other basic earth science-related data as shapefiles (file format that ArcExplorer can read). The students and teachers will also be given additional web sites that they could access data over the Internet, including the SPaRCE web page, as it becomes available.

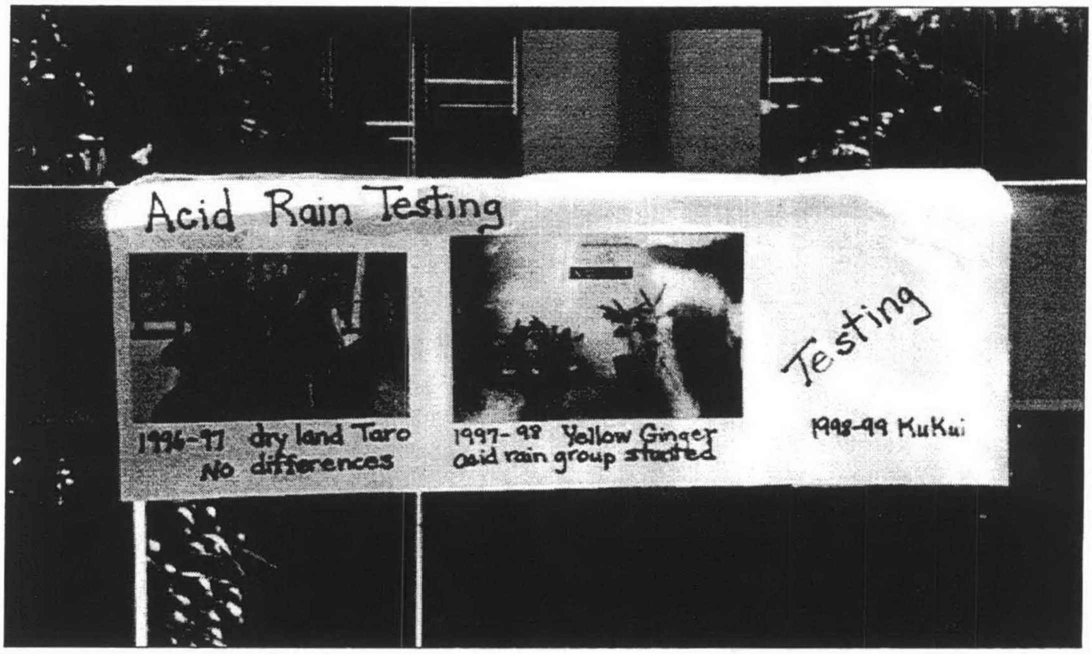

Figure 1.

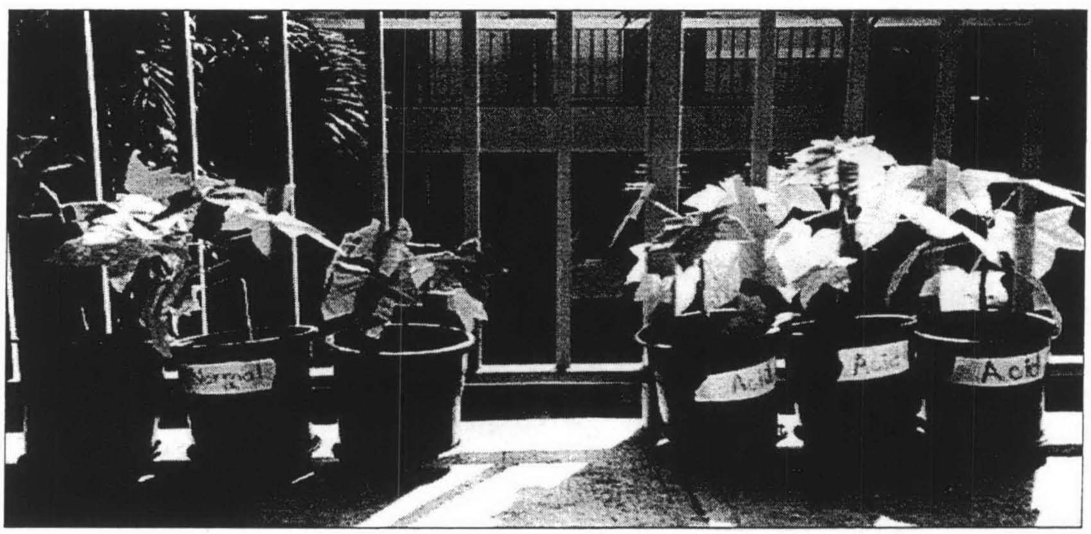

Figure 2.

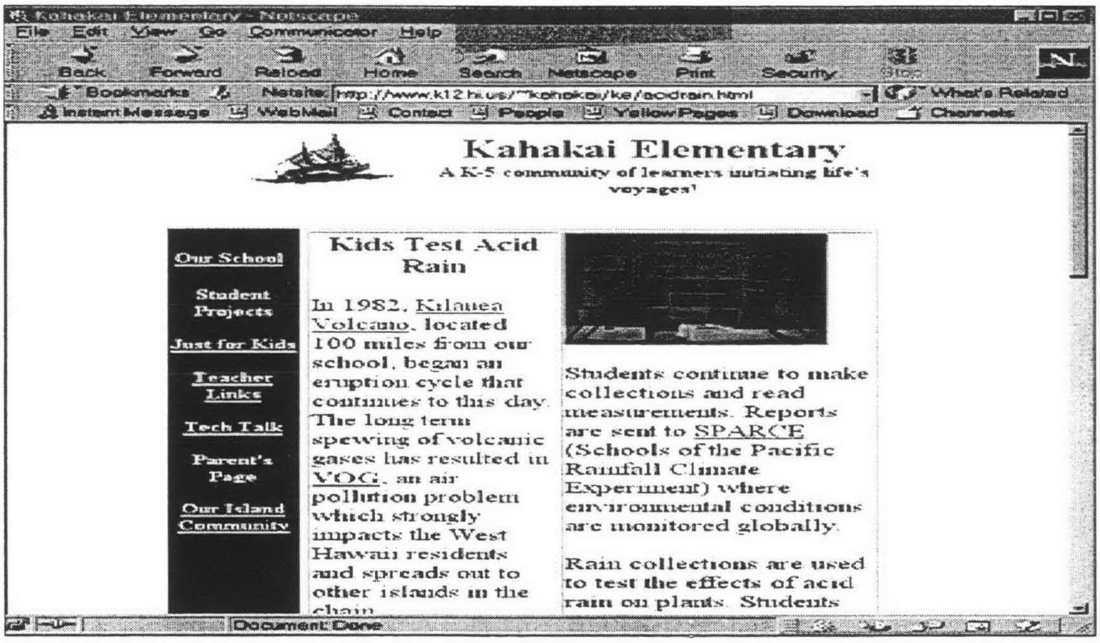

Figure 3.

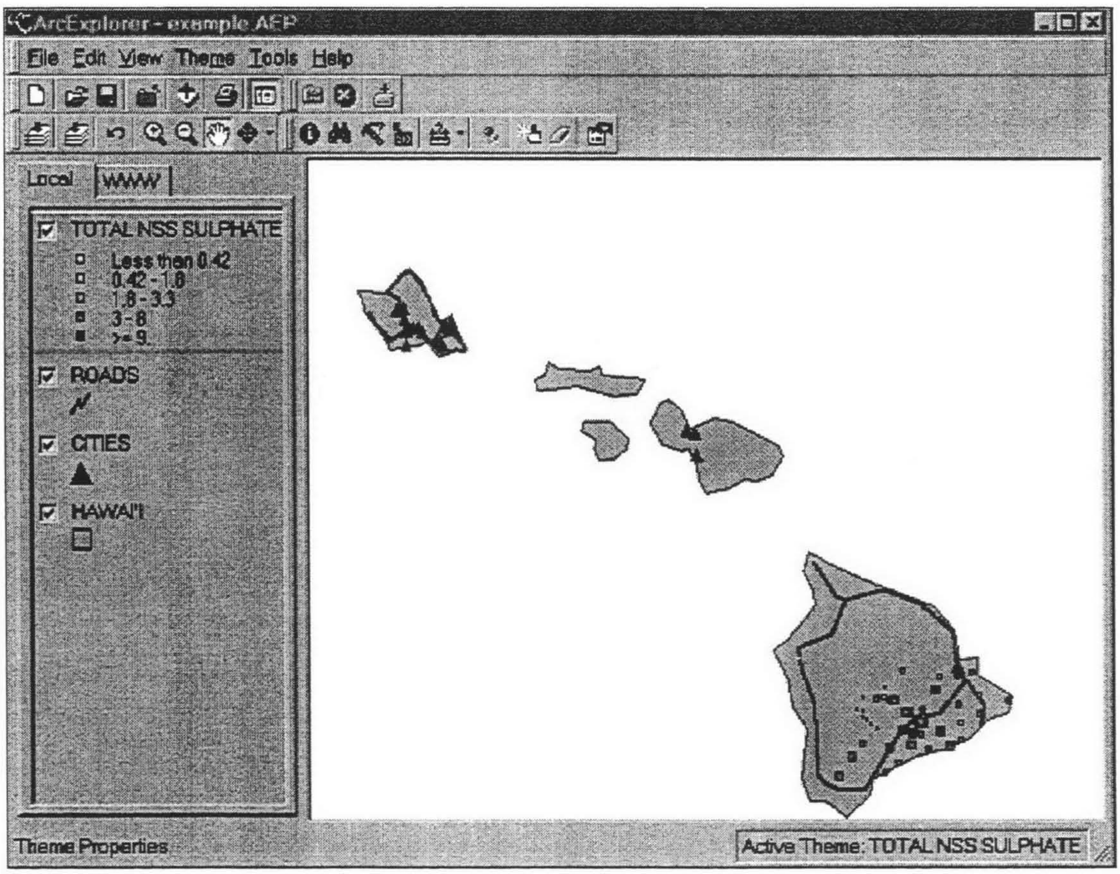

Figure 4.

Learn-by-Teaching : A Cooperative Program Between Princeton University and Local K-12 School Districts

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The Learn-by-Teaching program at Princeton University enables Princeton undergraduates in selected science, engineering and technology-related courses to develop and present science lessons to classes in local school districts, based on material from their courses. The teaching project replaces a specified course requirement, such as a term paper or the final exam. The objectives of this program are:

1. To provide undergraduates with an interesting, rewarding and memorable
2. way of learning in the sciences -- to "learn by teaching."
3. To motivate undergraduates to learn a particular area of science
4. extremely well.
5. To increase non-science majors' interest in and comfort with science.
6. To introduce interested undergraduates to pre-university teaching.
7. To enrich schoolchildren's experiences in science.
8. To foster interaction and exchange of resources between the university
9. and pre-university learning communities.

The current Learn-by-Teaching program at Princeton was initiated with National Science Foundation (NSF) funding in 1994, with the Department of Geosciences as a major participant. From experiences with many successful projects, the academic benefits for participating undergraduates, as well as community-service value of the projects has been increasing evident. McGraw Center for Teaching and Learning at Princeton is currently exploring the expansion of Learn-by-Teaching and assessing its long-range feasibility after the NSF funding has expired.

Role and Benefits of the Learn-by-Teaching Program for Princeton Undergraduates

A wide range of undergraduates participate in Learn-by-Teaching. Some plan to become teachers themselves, but many have simply enjoyed working with children in the past and see this as a rewarding way of fulfilling a course requirement. Others see this option as a way of exploring teaching as a career possibility.

Each student in Learn-by-Teaching is paired with and mentored by a 3rd - 9th grade school teacher and supervised by Learn-by-Teaching staff. The student designs and teaches a several day-long unit to the teacher's class of schoolchildren, on a topic related to material of the particular course involved. Students schedule their teaching towards the end of the term, near the culmination of their own learning experience. Consistent with science reform efforts in the region, hands-on science, with active engagement and involvement by the school children is emphasized rather than lecturing.

The Learn-by-Teaching project replaces a significant course requirement such as a term paper or final exam, and thus represents a serious academic commitment. Learn-by-Teaching staff work with participating faculty to ensure that the teaching project will meet the academic objectives of the course. After completing the teaching, students submit a paper documenting the lesson plans, the science material covered, and the teaching experience. Cooperating teachers are asked for feedback on the lessons. To determine the overall project grade, Learn-by-Teaching supervisors and course faculty evaluate the planning and effectiveness of the lessons, as well as the written report.

Undergraduates find it very rewarding to master a section of course material, design lesson plans, and transform themselves from students into teachers. One participant had a difficult second day of teaching due to disruptive behavior during the volcano simulation activity she had devised. However, the volcano "game" she devised for the students on the last day showed how much of the material the students had nonetheless grasped. She wrote "Their enthusiasm really manifested itself on the third day, which was wonderful, as it allowed me to leave [the school] convinced that I had taught the students something...[Learn-by-teaching] was one of the most rewarding things that I have done in quite a while."

Significantly, we have found that by participating in Learn-by-Teaching, undergraduates often make progress in mastering scientific concepts and are motivated to learn at a deeper level and with greater (and longer-lasting) interest than they otherwise would.

One student writes "Having to teach the things I've learned this semester ... really forced me to evaluate and reinforce what I know. In order to teach fourth graders, you have to break down and process complex ideas into a more simplified form, without distorting the science ... Forcing me to analyze the material make me more clearly see the progression and theory building -- something which can sometimes get lost amid the details of a Princeton course. The science is clearer and more real for me now, even though at a simplified level."

Another student writes: "I am certain that researching and preparing this project increased my personal understanding of volcanoes. Although it requires a much larger time and emotional commitment than studying for an exam would, I have not regrets at all about choosing to undertake this project. Besides being a great outreach project for the Princeton Community, I also think it is a more valuable "real life" experience than merely taking a three hour exam. In the long run, I suspect that I will also remember more from it, as I have been literally reading about volcanoes and thinking about this project every day for over a month!"

Role and Benefits of the Learn-by-Teaching Program for Local School Districts

Cooperation with and support by the local school districts is essential to the success of the program. We work in partnership with administrators, science coordinators as well as with the growing network of teachers who serve as mentors for the Learn-by-Teaching projects.

Geoscience is a part of most elementary and middle-school curricula in our area, so projects from geoscience courses are particularly well-received as exciting additions to existing curricula. The teachers and school children involved are also enthusiastic about having Princeton undergraduates in their classrooms, and the lessons are generally an exciting experience for the children. One teacher writes "[The undergraduate's] youthfulness and enthusiasm immediately captured the attention of her young learners. [Her] second lesson clearly demonstrated for the children how sedimentary rocks are formed. She began with a pebble and asked, 'where did this come from?' After brainstorming and orally extracting from the children the cycle of rock formation, [she] had the children re-enact the process through a play [and] the children internalized the concept in a fun and meaningful way ... [The undergraduate] generated interest from the students and kept them engaged. The energy level, inquiries, and knowledge base of the children were thoroughly increased...This was an extraordinary introduction to our unit on "The Changing Earth."

Two teachers in an urban school were particularly pleased about how all the children, including some who were know to be difficult to motivate, were engaged and excited by the lessons. They were impressed with the understanding of the material being taught, as shown by the school children themselves during review of the lessons.

Teachers have also benefited professionally from the Learn-by-Teaching program, which is only one of several programs at Princeton that foster interaction between the university and local school districts. One school superintendent noted that "[Our school district] is committed to the improvement of science, mathematics and technology education for all students. Our elementary faculty ... have found the ... Learn-by-Teaching projects in science to have been highly effective in stimulating teacher and student interest ... Faculty who have experienced professional growth opportunities through Learn by Teaching and [other programs at Princeton] have become majors movers in our science reform efforts."

Creating A Teaching Companion To This Dynamic Planet: Progress And Process

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In 1989, the U.S. Geological Survey (USGS) and the Smithsonian Institution produced *This Dynamic Planet: A World Map of Volcanoes, Earthquakes, and Plate Tectonics.* A second edition of the map, released in 1994, included editorial changes to increase the legibility of the map, added the locations of impact craters, corrected errors, and improved the explanatory text.

The wall map was exceptionally popular and widely distributed (nearly 50,000 copies); yet since its release, we have received numerous and continued requests from teachers for classroom materials that expand on the map's explanatory text. In response, a general-interest booklet called *This Dynamic Earth: The Story of Plate Tectonics* was published in 1996 to complement the map. The booklet partially filled the need, but additional classroom-specific activities and exercises are still being requested.

Since the *Teaching Companion* was first proposed in the early 1990s, many new ideas have surfaced and technology has changed dramatically. In addition, one of the original map compilers and early proponents of the *Companion* retired, and new staff came on board. After several delays, we are now in the final stages of creating the *Teaching Companion* to both the map and booklet. It is designed to assist teachers in using the map in the classroom, and to teach plate tectonics in grades 6-14. The *Teaching Companion* will not be simply generic educational material on plate tectonics, because an abundance of such material already exists. Instead, the project focuses on the development of classroom materials specifically geared to the existing USGS plate tectonics map and booklet. Our aim has been to develop a high-quality, focused assemblage of classroom activities, black-line masters for reproduction, student maps, explanatory text, references and resources, and other materials to facilitate the teaching of a unit on plate tectonics at a middle- to high-school level. Teachers will have a package consisting of 3 interrelated components: the two existing USGS outreach products on plate tectonics (*This Dynamic Planet* wall map and *This Dynamic Earth* booklet), and the new *Teaching Companion*. The trio will be made available as a package for little or no cost to teachers.

The USGS will distribute the *Teaching Companion*, bundled with the original map and booklet, through its established distribution channels and at various teacher conferences. We also seek to collaborate with other organizations for additional distribution to educators of students who are usually under-represented in the Earth sciences, and to teachers of subjects other than Earth science.

Previous updates on the progress of the *Companion* have been published as abstracts at the Second International GeoScience Education Conference (GeoSciEd II) in July, 1997, and at the annual meeting of the Coalition for Earth Science Education (CESE) in October, 1998. Those meetings proved to be excellent sources to find teachers and others, as participants, collaborators, and partners for the project.

Much of the writing, compilation, and review for the supplement has been done by teachers and scientists working together in a series of workshops. In August 1998, 17 teachers from across the U.S. came to Menlo Park, California, to begin creating the *Teaching Companion.* A second workshop in late June, 1999, focused on reviewing, editing, and revising the draft document.

During the first week-long workshop to develop the *Companion*, participants devoted about half their time to learning about the latest scientific developments in the field of plate tectonics from USGS and other researchers. The remaining time, teachers worked in small groups creating a series of draft activities and related resources in the areas of natural hazards, natural resources, the historical development of plate tectonic theory, and understanding plate tectonic motions and boundaries.

The second week-long workshop included a few teachers from the first group, a few teachers new to the project, and USGS scientists. We focused on revising and rewriting earlier draft materials and creating new materials as necessary to fill gaps.
We are currently seeking middle- and high-school classroom teachers to field test and review the draft materials during the 1999-2000 school year. We also seek other educators and scientists to assist with the continuing review and improvement of the *Teaching Companion.*

The *Teaching Companion* has been developed with the idea that not everyone has access to the Internet, nor is interested in high-technology learning. The *Companion* is self-contained, and the activities call for few materials, most of which are inexpensive and easily obtainable. However, for those classrooms on the cutting edge of technology, the map and book are on the Internet, <http://pubs.usgs.gov/pdf/planet.html> and <http://geology.usgs.gov/publications/text/dynamic.html> respectively, and we have listed World Wide Web resources for most of the activities.

We will publish the *Companion* in loose-leaf form, not only to make it easy to remove pages for photocopying, but also to add new or revised material conveniently. Any of the black and white illustrations can be photocopied on plastic transparencies for use with overhead projectors. Likewise, color illustrations can be made into color transparencies or photographed to make 35-mm slides.

The materials are meant to be integrated easily into existing curricula and to supplement other lessons about plate tectonics and its influences on our planet and on people.

The *Teaching Companion* contains classroom activities covering five basic areas; teaching tips on how to use the *Companion;* print and electronic references to guide further exploration; an overview of the basic principles of plate tectonics (science concepts); extra illustrations and maps that have multiple uses with any curriculum; references to guide students in further exploration; and (missing from the original booklet) a table of contents, index, and errata for *This Dynamic Earth.*

The activities included in the *Teaching Companion* are organized similarly to the booklet, *This Dynamic Earth,* with sections on "The Basics," "The Development of a Theory" (history, evidence, and evolving human thought), "Understanding Plate Motions," "Human Connections" (natural hazards and resources), and "Out of this World" (extra-terrestrial plate tectonics). These activities put some new spins on old favorite lessons, such as learning the layers of the Earth and plotting locations of earthquakes on a world map, and then progress to lessons on tectonic landforms, tsunami propagation, Earth resources and politics, and investigating the possibility of tectonic activity on other planets in our Solar System.

All activities are cross referenced to the map, or pages in the book, and are correlated with both the *National Science Education Standards, and Geography for Life: National Geography Standards, 1994.* Although science and geography are two obvious curricular areas in which to teach plate tectonics, we hope that our notes on curriculum links in each activity make it easy to include them while studying history, economics, and other social studies.

To make the material easy to use, all activities in the *Teaching Companion* have the following format:

Title

Overview

(summary of activity)

Objectives

(what students should learn by doing the activity)

National standards references (References and citations are given for both the National Science Education Standards and the National Geography Standards. Although several activities can meet the standards for other curriculum areas we did not cite those.)

Links across the curriculum

(suggestions on how and where to use the activity in other than a science lesson, e.g. math or language arts)

Materials (lists)

for teachers

for each student group

Reference to *Dynamic Earth* booklet & *Dynamic Planet* map

(page and location references for content background, or as a starting place for the activity)

Content background for teacher (additional information specific to the activity, but not covered in the *Dynamic Earth* booklet)

Instructions for activity

(including teaching strategies)

Teacher answer key

Extensions

(supplemental activity suggestions that can be used if there is extra class time, or can be given to students as homework)

Additional resources

(Web sites, books, other USGS publications that are very focused and specific to the activity. A general Reference section is in the back of the *Teaching Companion.*)

Assessment suggestions

(follow-up and testing student learning)

Teacher masters

(can be used to make transparencies, slides, posters, etc.)

Student pages (masters for duplication and handouts)

The original map and booklet garnered awards, and were hailed as beautiful and full of excellent information, yet few teachers were using them directly in the classroom, as part of the curriculum, or in a lesson. Our goal in producing the *Teaching Companion* is to assist teachers and students in moving beyond regarding the map as wallpaper, and to use the booklet as more than a collection of pretty pictures. We hope to guide teachers and students in considering the information in the map and booklet in a broader context, and possibly to discover new insights into plate tectonics.

An Interdisciplinary Curriculum Development Workshop on Environmental Change

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Introduction:

A special report entitled *Geoscience Education: A Recommended Strategy* (NSF 97-171) highlighted the necessity of pro-viding elementary and secondary students with the opportunity for hands-on/minds-on discovery using the most advanced data and techniques. This document and the National Science Education Standards also express the desire to have interdisciplinary curriculum. To address these needs, teachers will have to develop and/or enhance their skills to use and analyze data. In addition, science educators need the opportunity to interact with teachers from other disciplines to create interdisciplinary units.

Because the topic of global environmental change is inherently interdisciplinary and there are substantial data resources available, we developed a workshop entitled, Process-Oriented Environmental Change Education. The term, "process-oriented," refers to both the process of science and the process of inquiry-based education.

This paper describes the extent to which this workshop helped teachers to: 1) enhance their science content knowledge related to environmental change; and 2) provide an opportunity to develop interdisciplinary units.

Workshop Design:

This workshop is an integral part of the ongoing efforts of the Nebraska Earth Science Education Network (NESEN) to use multiple strategies to improve science education. This educational outreach project is funded by the Great Plains Regional Center (GPRC) of the United States' Department of Energy's National Institute for Global Environmental Change (NIGEC). The primary goal of these workshops is to provide an opportunity for K-12 educators to incorporate environmental change data and information into their current curriculum while supporting the vision of the National Science

Education Standards in which learning science is an active and inquiry-oriented process.

To create this professional development activity, a two-day planning workshop was convened in September 1996. Participants included: six K-12 educators from rural and urban schools, three 4-H extension educators, four pre-service science teacher educators, three NIGEC scientists and the director of the GPRC. Also participating were three experts in the assessment and one on the national science standards

The discussions between these stakeholders highlighted one of the greatest obstacles to improving science education both nationally and locally: the limited formal training and lack of experience many teachers have in "doing science." In addition, it was also strongly suggested that participants in the workshop consist of multidisciplinary teaching teams. The reason for these teams are: 1) students retain information better if it is examined from different perspectives; 2) teachers can provide support for each other once they return to their school; and 3) this approach allows for science and other aspects of the curriculum at individual schools to simultaneously evolve in the context of local curriculum requirements.

Workshop Implementation:

The multidisciplinary teams consisted of at least one earth science teacher and at least one teacher from another discipline. Workshops were conducted during August 1997 and 1998. Eight teachers participated in 1997. In 1998, 13 teachers representing six different rural and urban high schools participated. Each team was required to produce a minimum of a five-day inter-disciplinary unit on environmental change. In some cases, the new units were longer than five days because of the interest of the educators. In addition, each team was required to present a workshop to at least 10 other educators. An electronic portfolio of these activities are available at http://nesen. unl.edu/nigec/ activities/ env_ed1.html).

Workshop Content:

The National Science Education Standards (NRC, 1996) provided the criteria for the organization and modeling of the scientific process within the workshop. We also wanted to provide a better understanding of the Earth as a system. We used an approach modified after Sneider and Golden (1996) that recognizes that everything is connected to everything else and each part of a system responds to exchanges of energy and matter.

Each workshop began with an introduction to the concept of systems followed by its application to elements of key subsystems of the earth including the atmosphere, hydrosphere, and biosphere as well as human interaction with these subsystems. Because the participants were from Nebraska, we focused on aspects of these subsystems that would be applicable to their local environments.

Assessment Instruments:

The following questions provided the framework for our evaluation:

1. How can the quality of the workshop be improved as it proceeds?
2. How did the teachers view the workshop after it concluded?
3. Were the goals and objectives of the workshop met?
4. Are teachers able to implement a unit on global environmental change?

To improve the quality and the process of the workshop, we asked each participant to assess our approach and activities at the end of the each morning and afternoon session. These formative surveys helped to determine what worked, what did not work and what should be changed. Evaluation of the formative data after each session indicated that we were generally on target with our materials and approach.

A wrap-up survey was designed to address questions 2, 3 and 4. Quantitative questions sought information regarding workshop content; goals and principles advocated by reform; and teacher efficacy. Three qualitative questions were also asked in terms of what was most beneficial, suggestions for improving the workshop, and contributions that the workshop made to the development of an interdisciplinary unit.

Data Summary:

Overall, 96% of the teachers were satisfied with their level of participation. Teachers thought the goals and objectives of the workshop were clear, the instructional methods suitable for the stated goals and the content understandable and logically presented. More importantly, the inquiry and interpretation exercises helped to expand their scientific knowledge and skills. About 70% of the participants indicated that they would be able to use the workshop materials in their classrooms.

In addition to expanding their scientific knowledge and skills, more than 75% of the participants indicated that they had learned to use technology to enhance their teaching because of the workshops. Teachers said they learned new ways to integrate science, technology and other subjects in the classroom.

More than 75% of the educators indicated that their workshop experience was the type of active learning environment that they individually try to provide for their students. Almost all the teachers indicated that they would be able to develop an interdis-ciplinary unit on environmental change, but only 71 % acknowledged that they had a concrete plan to implement it. Nearly 80 % of the 1998 participants had a specific plan because we provided additional planning time when compared to the 1997 workshop.

Collegiality was a consistent theme when teachers were asked what contribution the workshop made to the development of an interdisciplinary unit. Teachers cited the most beneficial aspect of the workshop was the time to meet, converse, share with and learn from other teachers. Qualitative responses indicated that teachers are not normally provided time to discuss ideas and information about how to create an interdisciplinary unit.

Only 63% and 46% in 1997 and 1998, respectively, indicated that they could implement the approaches to learning that are advocated by national and state science standards in their units. These low values are not surprising considering that only about half of the participants were familiar with either the national or state science standards because they represented other disciplines. Another aspect related to implementation of the standards is that less than 60% of the teachers felt confident that they could help their students interpret results consistent with accepted scientific understanding.

Although the familiarity with the specifics of the science standards is low, educators supported many of the concepts advocated in the standards, especially related to using hands-on approaches. Ninety three percent of the educators indicated that connections need to be made between science concepts and real-world applications. Eighty percent indicated that students also learn best when they struggle with real world problems. All science teachers and nearly 90% of all the participants indicated that it was important to consider student's conceptions about natural phenomenon when planning curriculum.

Discussion

Our data clearly indicate that the workshop met our goals and objectives as well as being well received and helpful to the teachers. One of the most beneficial aspects of the workshop was the collegial environment. Our workshop provided an opportunity for teachers to meet, converse, share ideas with, and learn from other teachers. Providing time for curriculum planning was critical because participants are not necessarily given the opportunity to work with teachers from other disciplines to develop interdisciplinary units. One participant commented that "it (the workshop) provided compensated time to work with a colleague in developing curriculum. This seldom, if ever, happens in our school setting."

If there is going to be the integration of science concepts with other areas of the curriculum, then professional development opportunities must be provided to accomplish this objective. Our limited data indicates that these opportunities are generally not available. Meaningful opportunities for educators to interact and develop interdisciplinary curriculum need to be created at the school level. This will allow curriculum be developed that is consistent with local curriculum goals and objectives.

We presented the concept of systems in a workable manner. Participants noted they liked the systems approach because it provided the framework necessary to look at environmental change with a broader focus. Our activities helped participants recognize that "everything is connected to everything else."

Although hands-on experiences are an integral part to active learning, science teaching also needs to engage the brain and involve students in inquiry-oriented investigations. Inquiry-oriented science education allows students to become actively engaged in the scientific process which involves investigation, critical thinking, imagination, intuition, and thinking on your feet and with your hands. (Bower, 1996).

Although the teachers are trying to engage their students in "active learning", fewer than 60% of our participants agreed they are confident in their ability to interpret results consistent with accepted scientific understanding. This result is not surprising considering that most teachers have not had the opportunity to work with data or to provide their own interpretations. To acquire these skills requires experience and training that is generally not available to educators. A critical benefit of this workshop was the opportunity provided for the teachers to develop and practice these skills. We spent a significant amount of time explicitly discussing the uncertainty of science through group discussions and problem solving activities. Even though they may have lacked confidence at this point, they did gain valuable experience.

We clearly need to find ways to boost teacher confidence in interpreting data using accepted scientific practice if implementa-tion of inquiry-based learning is going to take place.

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The Establishment of the School-Centered Network of Science Learning in the Age of the Lifelong Learning Society

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Abstract

It is important to establish the learning system to learn at every time and in every place in the lifelong learning society. But the learning system in Japan is not satisfactory. Because the school education is not only unified with the social education but is also isolated from that. Students and teachers at secondary schools think most highly of how to pass the entrance examination. Therefore teachers teach and train students how to solve the problems for it. They have spent a lot of time on problem-solving and drills. They could not spend the ample time and scope for the inquiry task, the research task and the fieldwork which took more time. Considering the real purpose of education at school, teachers should think more highly of improving students' various abilities in addition to the ability to answer questions and solve problems. Teachers must make students foster the ability, interest and attitude, and skill to continue to learn through their life. But teachers don't have a plan to make use of the social facility in their lesson, invite an instructor out of school and design to exhibit the research work of students out of school. Teachers must show that learning is not only for the entrance examination but also for enrichment of our life through our daily lessons. Learners (both Students and teachers) expand their world through learning, find out their identity and how to live ,and enjoy their life. I insist that learning at school be needed to develop the base to enrich and enjoy the life, and such learning be needed for the lifelong learning society.

I would like to propose the following proper science education and education system (network). I have developed the curriculum in which fieldwork (outdoor learning) is centered. In this curriculum I have made use of the social facility like the museum and the social personnel, and made opportunities to exhibit students' works in their local facility and made students communicate their research tasks and works with many students and people out of their school. Now I am trying to let students communicate their works with students in other schools and people out of school through the Internet for further development and improvement of school learning system. Students will expand their learning organically from school to native place, from school to the world in the end. They will make organic use

of various networks and develop their learning expansively. Therefore Such a method of science learning as this is defined as "The Organic and Expansive Learning".

The organic and expansive learning thinks highly of the learning network. The learning network has many hierachies (levels). For example, the network of subjects, the network of students' communication, the network of school and facilities out of school (the school centered network), the museum centered network, the network of Internet, the network of nature observation, the network of Mass Media and so on.

The reason for the fieldwork centered curriculum

1. Students like field work.
2. Students can develop their inquiry task according to their ability level in the fieldwork.
3. Many people (adults) have their habit related with nature. Children and adults can share their habit in the nature. Therefore the fieldwork has something to do with lifelong learning.
4. The fieldwork has much to do with many subjects. Therefore the network among subjects can be easily established.
5. Students can easily be assisted their study by the curator and specialist in the local museum.
6. The fieldwork is related with our daily life and can be developed with the collaboration of the local people.
7. Students can access such many networks as (5) & (6) with relation to the fieldwork.
8. Students investigate flora and fauna, and geological aspects in their local area and develop their learning to the world by comparison.
9. The real experiences and real matters (like hands-on) is important in the education instead of reading books and watching pictures.

Teaching Method

Organic and expansive learning method

Teacher's role

1. Holding the interesting lesson
2. Assisting the student's research
3. Coordinating between students and specialists

The Developed Curricula (If you request the abstract of the curricula, I will present them to you.)

(1) 7^{th} grade level science: the curriculum of flora and fauna field work

(2) 9^{th} grade level science: the curriculum of geological aspects

The Established Networks

(1) Interdisciplinary curriculum network in school

(2) School-centered network

(3) Museum-centered network

The developing Networks

(1) Mass Media Network with relation to nature observation

(2) Internet Network with relation to nature observation

(3) Internet Network between school and museum

Manuscripts

(1) Interdisciplinary curriculum network in school

(2) School-centered network

(3) The Curriculum in the 7^{th} Grade (Flora and Fauna Field Work)

Revolution in Australian Tertiary Geological Education

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Geological education in Australia is undergoing a revolution in response to economic pressures. Departments have been downsized or amalgamated over much of the country. Associated with reduced per capita funding is a change in the employment pattern and company support to university geology departments. The pattern of employment has always been somewhat nebulous but currently is it affected by dramatic changes in commodity prices (eg. gold), land availability, and especially economic irrationalism. Economic irrationalism is essentially short-term gain for long-term pain, and has resulted in some large companies slashing exploration programs, and other companies following suite in copycat mode. Employment for exploration geologists is at an historical minimum. Environmental geology was thought to be the great new employer as mining receded, following the American example, but it still has a long way to go.

Associated with departmental amalgamation has been a fashion to regard disciplines such as geology, chemistry and physics as old fashioned and out of tune with the needs of the modern world. Now the fashion is to go for a multi-disciplinary approach which disintegrates the old disciplines and recombines some of the elements into more fashionable units such as environmental science. Computers are inevitably playing a bigger role in teaching. This is spurred on by the cost savings that virtual laboratories can make. Hopefully they will not completely replace real laboratories. There seems to be fewer excursions now because of cost, and flexible delivery is being promoted by the establishment. Already I have one excursion that students do alone following written instructions.

Pressure on staff levels has caused amalgamation, retrenchments and staff attrition. Enrolments have been increased or disguised throughout Australia by integrating geology with biology (directly or through environmental science), by integrating with geography and by integrating with civil engineering. Going multi-disciplinary or interdisciplinary has also been useful for producing a smoke screen around enrolment numbers and looking trendy at the same time.

There appears to be a greater demand now for education beyond one degree to gain employment as a geologist. This is not being met so much now by PhD programs as before mainly because they are not very cost effective. Honours degrees and second degrees are now popular and double degrees are becoming popular. There also appears to be a new tendency for advanced geological education to move away from universities to mining companies.

On-going post-graduate education is a diversifying field and will probably see more diplomas given for aggregate completion of otherwise stand-alone modular units delivered in a flexible manner. Umbrella cooperatives such as VIEPS (Victorian Institute of Earth and Planetary Sciences) will cement institutions together to form relatively strong structures, and industry is likely to become even more involved with post graduate teaching than hitherto.

Directed Research as a Means of Inspiring Students in the Geosciences

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Many students accuse educators of failing to make science courses exciting or relevant to their interests. In some cases, their complaints may be legitimate. Science courses frequently require in-depth discussions or theoretical concepts that many students cannot directly apply to their goals. In geology, for example, we need to talk about abstract processes operating in distant lands that most students will never directly observe. They question the significance of this material, conclude that it is irrelevant (at least to them), and then shut down for the remainder of the lecture, laboratory, or field excursion. The constant development of new technology is also forcing educators to add more material to their curricula while retaining everything else. Even inspired students are at risk of burn-out with the shear amount of data that they are required to learn and retain. As educators, we should also be stressing independent thinking and scientific reasoning (i.e., observe, hypothesize, test, revise). Given the amount of "stuff" that we have to teach, this is a daunting task even for the most accomplished teachers.

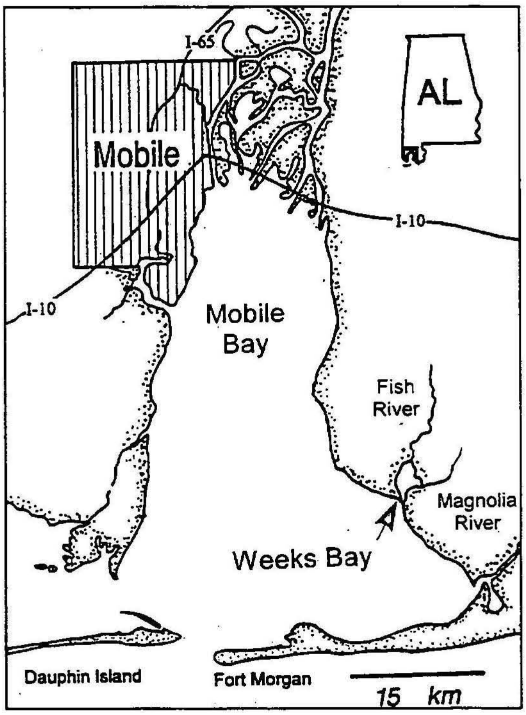
In our experience, we have found that independent thinking and scientific reasoning are best developed in students who conduct applied research during their normal course of studies. We are not referring to honours-level research that students commonly complete at the end of their undergraduate education, but to smaller-scaled, focused projects that are designed to be completed within a specific interval of time (usually one semester) along with other courses. The project can be done anytime during a student's undergraduate residency provided that they have received the appropriate background training. However, we feel that it is best for students to do research as early as possible (e.g., during their sophomore year), because they get a taste of what researchers do, and put themselves in better positions to make decisions about future careers. Early research experience has also proven to be an excellent means by which to recruit students into the earth sciences. Freshman and undecided students see that their colleagues are involved in meaningful activities and also want to get involved.

We have occasionally added research components to existing courses, but we feel the best route is to develop a specific project in a stand-alone course. This recognizes the importance of their work and factors their research into their semester workload rather than adding to it. Many universities (ours included) have a one semester directed studies course that is well suited to independent research such as what we are advocating.

Significant preparation by the student and the educator is required before a project can be started. The student must first be evaluated as to whether he or she is ready to conduct independent research. If they have not yet completed background courses in a particular subject (e.g., petrology), then they are clearly not ready to do research in that discipline; however, they may be qualified in other areas (e.g., sedimentology). The first thing that must be done by each student wishing to undertake a research project is to find a mentor who is willing to supervise the study. We have found it best to employ a "research agreement" (or contract) that defines the scope of the project, the responsibilities of the student, and the means of assessment. It is also recommended that the project duration be clearly stated on the agreement. Because it is "fun" (at least it should be), some students would prefer to continue their research for as long as possible, even at the expense of their other courses. One of the hardest tasks for the educator is to define a specific study for each student that he or she is mentoring. The project should be gratifying, relevant to a student's interests and something that can be done within the agreed-upon time frame. If an educator is familiar with an area, several different topics are probably readily identifiable; however, the easiest solution is to develop student projects from the mentor's own research activities.

For example, we are presently conducting a research study examining the sedimentology and stratigraphy of Weeks Bay, an estuarine embayment located in southern Alabama close to our university base (Figure 1). We identified several tasks that could be undertaken by undergraduate students and presented them to interested students as potential research topics. In some cases, the students revised the projects according to their own interests. At the present time, one student is examining the biostratigraphy of cores extracted from the bay. Four others are working as a team to map out bottom sediments that underlay the bay. This group approach has proven to be most effective for labour-intensive activities, as it tends to spread the work among several participants. It also teaches cooperation and responsibility since all of them must finish their components in order to satisfy the scope of the project. All students, whether working in a group or working on a specific project, become part of the overall research team.

Figure 1: Location map of our Weeks Bay research area. For logistic reasons, student research areas should be based as close as possible to "home."



In our case, the team consists of faculty and undergraduate students, but other institutions may involve other personnel such as graduate students or post doctoral fellows. It is also possible to involve others in the community in these research projects. For example, we are currently planning a new research project that contains components suitable for high school teachers and students. Teachers would receive graduate credit for their participation.

Developing undergraduate research projects can prove beneficial to educators and their host institutions. Our grants have received high praise for their level of undergraduate involvement, and in at least one case, we were funded because of that component. We now routinely apply for funds to cover the expenses of undergraduate research including course tuition costs. Undergraduate funding is particularly desirable

Figure 2: Scanning electron microphotograph of a portion of shell in limestone examined in an undergraduate research project. Field of view = 3

mm.

if the student's research involves analytical work (e.g., Figure 2) or incurs other expenses such as computer time or travel etc.

Benefits to the students are many. Not only do they learn to think, but they also gain confidence in their ability to think. Many of our students have delivered papers at regional and national conferences and several have been awarded for outstanding presentations. Undergraduate students who have presented results of their research activities in a conference setting are desirable as graduate candidates. They should therefore have less difficulty entering graduate schools if they choose to continue their education past the baccalaureate level.

The majority of our undergraduate research projects have ultimately proven successful, but we have experienced a few failures. One or two students began their research with the best of intentions of completing it, but for personal reasons, they were forced to quit. Frequent meetings with students may identify potential problems, and if caught early, the problems may be resolvable.

The EARTHWORKS project:Collaboration between a university geoscience department and an interactive science centre

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The introduction of earth sciences into the New Zealand school curriculum in 1993 had been long campaigned for[1] · Rather than its being a separate subject, the curriculum document[2] identified "Understanding Planet Earth and beyond" as a "learning strand" within the new curriculum. The relationship between this and related strands, and the broad subdivision of geological topics at particular levels of the curriculum is shown in Figure 1. Some elements of earth sciences have long formed part of the geography syllabus, but many science teachers were anticipated as being unfamiliar with the subject. There are abundant books and videos available, particularly on the more dramatic aspects of earth sciences such as earthquakes and volcanoes, and sets of rocks and minerals are commercially available. There has even been a recognition of the need to publish guides specifically for school field trips, to complement those prepared for a more general audience[3]. However worthwhile field excursions and the study of rock and mineral specimens may be, it is difficult for many people to conceive of the processes that give rise to the landscape they see or the earth materials they touch. And, of course, I many of the processes are either too slow, like weathering; too fast, like earthquakes; too dangerous, like volcanic eruptions, too inaccessible, like mantle convection; or on too large a scale, like the movements of tectonic plates for students to experience them first-hand. It was the intention of the "Earthworks" project to provide an interactive experience of such processes.

Two other factors made possible an interactive exhibition featuring a variety of earth science processes and an associated learning programme aimed at middle school students. These were:

- the opening of an interactive science centre, EXSCITE[4], in Hamilton in the mid- 1990s
- the withdrawal of Ministry of Education funding for education officers in established museums and the re-allocation of those funds to a contestable pool to which museums, science centres, zoos and other institutions and organisations offering "learning

experiences outside the classroom [LEOTC]" could apply.

On the basis of these three factors, the University of Waikato's Department of Earth Sciences, in association with the Exscite Trust[5] made a successful application to the Ministry of Education for a substantial contract to develop an exhibition which sought to demonstrate as in interactively as possible some of the processes that form and modify the Earth's surface, on a scale of time and space that could be appreciated by students during their visit to the science centre (typically about 1.5 hours). Recognising that many teachers were unfamiliar with earth sciences, the contract also provided for introductory workshops, so that teachers could receive background information about those aspects of earth sciences portrayed in the exhibition and could "play" with the exhibits, uninhibited by their students, before their classes attended. In addition, a comprehensive teachers' resource provided numerous ideas for teaching the geoscience component of the curriculum in a similarly interactive way to the exhibition [6].

The management team for the "Earthworks" project included a small group of experienced teachers, selected on the basis of a known commitment to innovative teaching, and with some knowledge of earth sciences. This group had input into the selection of concepts that were to be used in the exhibits, and were particularly involved in the preparation of the teacher resource. Mindful of the relationship between age and effectiveness of engagement with interactive exhibits[7], the exhibition was targeted at Forms 1-4 (levels 4- 6). It so happens that this corresponds to that part of the science curriculum whose earth science component is concerned with plate tectonics, geological hazards, erosion and mining that lends itself to interactive exhibits. At lower levels, the earth sciences "strand" in the curriculum tends to stress the properties of materials; at higher levels, the environmental and societal implications of Earth's processes.

The construction of the exhibits was undertaken by EXSCITE staff and outside contractors to design briefs prepared by the project team. Exhibits in science centres more typically portray aspects of physics and technology, and, thus, there was little previous experience of designing and building geoscience exhibits from which to draw. Some twenty exhibits were constructed[8]. Some effectively modelled actual processes, but on a smaller scale, e.g., the operating geyser, the walk-in earthquake simulator, the wave-maker, the flume for demonstrating the effects of stream erosion, the giant sedimentation tank. Others were simulations of earth science processes, e.g., the use of 'stud-finders" to map hidden conductors, to simulate geophysical prospecting; the expulsion of compressible balls from a chamber, to simulate volcanic eruptions; a vertical jigsaw, to demonstrate stratigraphic relationships. Because two of the curriculum's aims are to advance learning in science by "developing students' understanding of the evolving nature of science and technology" and by "developing students' understanding of the different ways people influence, and are influenced by, science and technology", there were also a few exhibits that attempted to show the development of scientific ideas. These included a mechanical model of plate tectonics, and a large version of a micro-plate model to show the tectonic development of New Zealand[91.

The exhibition toured New Zealand's four operating science centres in Hamilton, Palmerston North, Christchurch and Dunedin during 1995 - 1996 and was visited by some 20,000 school children. Introductory workshops, each attracting about fifty teachers were held at each venue prior to the exhibition's opening there. At those workshops we sought information from attendees of their knowledge of earth sciences and their experience in teaching the subject, either as part of the geography syllabus or within the science curriculum. The results of these surveys suggested that many teachers lacked confidence in and understanding of the subject[10], for some, at least, that was the motivation for attending the workshop. The teachers reacted well to the opportunity to preview the exhibition, and gladly accepted the resources[6] provided. Surveys conducted at the time of their subsequent class visit revealed a high level of satisfaction with the visual appeal of the exhibition and its effectiveness in portraying geological processes. While they felt the exhibition would be likely to enhance student attitudes to earth sciences, they considered it of greater potential benefit to their teaching than their students' learning.

However, we were concerned to know what the visiting students learned from their experience. Much of the evaluative research in science centres mimics that done in museums, and concentrates on monitoring visitor numbers and the length of time visitors spend with a particular exhibit. Such studies tend to assume that the longer the time spent at an exhibit, particularly if there are other signs of "engagement", the more the concepts or ideas it portrays are understood. Accordingly we undertook a series of interviews with students who attended the exhibition, particularly seeking information on whether they made the "connection" between the model or simulation and the geological process it sought to portray. The companion paper presented at this conference by Kathrin Otrel-Cass describes the methodology used and the results obtained for this part of the project.

[1] See, for example: Lee, D. (1993). Science in the New Zealand curriculum: making sense of Planet Earth and beyond. *Geological Society of Ne," Zealand Newsletter*, no. 103, pp. 1-2.

[2] Ministry of Education (1993) *Science in the New Zealand Curriculum Wellington:* Learning Media.

[3] The Geological Society of New Zealand has published a series of guide books targeted at a general audience.

[4] EXSCITE (Explorations in Science and Technology) was the last of an initial six such centres to open in New Zealand. The development - and partial demise - of the science centre movement in New Zealand is described in Hodder, A.P.W. (1997). Science-technology centres and science education in New Zealand. Pp. 141 - 155 in Bell, B. and Baker, R., *Developing the Science Curriculum.* Auckland: Addison Wesley Longman.

[5] The Exscite Trust is an independent charitable trust established at the initiative of science faculty staff at the University of Waikato to establish the EXSCITE Centre, and was responsible for the centre's management during the period of the "Earthworks" contract.

[6] This was originally published as a "working report" (Hodder, P.; Hume, A.; Jenks, A. and Peters, J. (1996) Earthworks: the teachers' guide. *Department of Earth Sciences, University of Waikato, Occasional Report,* no. 20), but a revised version is being published by User Friendly Resources of Christchurch, for Australasian distribution.

[7] This was based on research by: Boisvert, D.L. and Slez, B.J. (1994). The relationship between visitor characteristics and learning associated behaviors in a science museum discovery space. *Science Education,* vol.78,pp. 137-148.

[8] These are described in: Hodder, A.P.W. (1996). Earthworks: a guide to the exhibition. *Department of Earth Sciences, University of Waikato, Occasional Report*, no. 23; and will be featured in this presentation.

[9] This was a greatly enlarged version of a model distributed by the late Harold Wellman at a Geological Society conference in 1986. Wellman was the first New Zealand geologist to recognise the potential of plate tectonics to explain the geological development of New Zealand.

[10] Hodder, A.P.W. and Otrel-Cass, K. (1998) Teacher attitudes and knowledge of geoscience in New Zealand: a small scale survey and some implications. *Waikato Journal of Education,* vol 4, pp. 135-140.

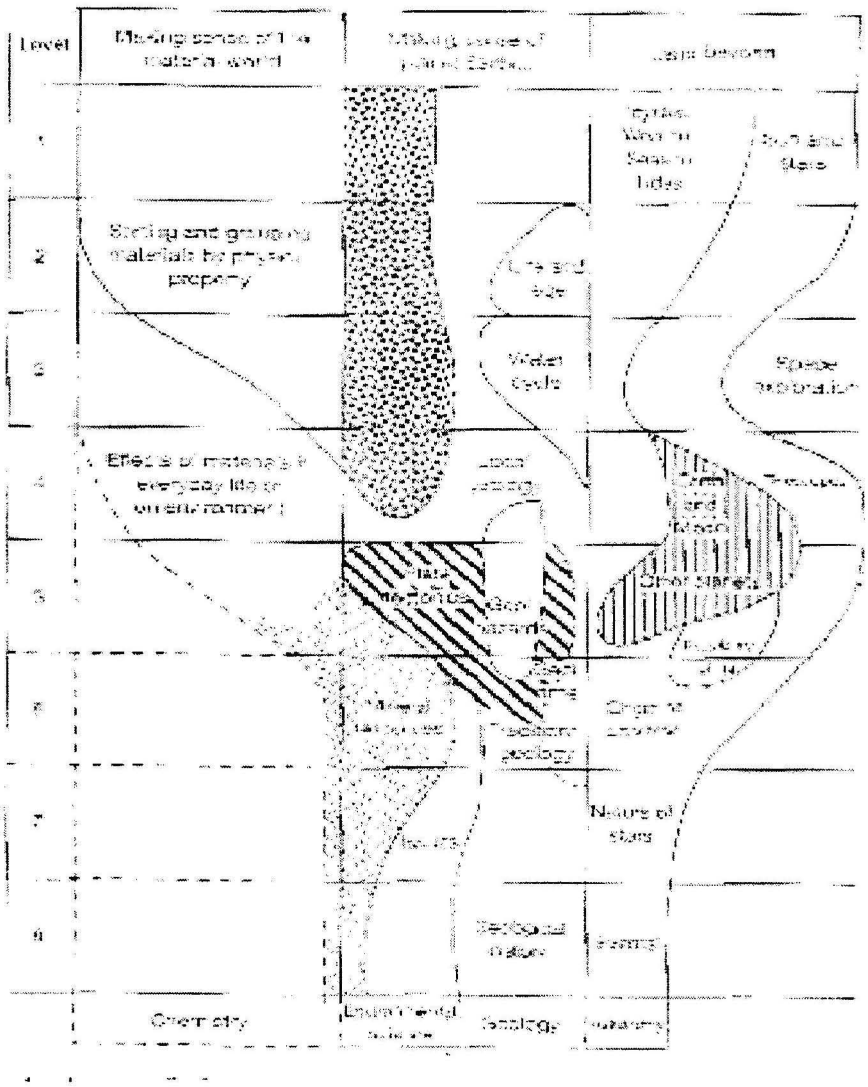

Figure 1. A compilation, showing the place of earth science topics in the "Making Sense of the material World" and "Making Sense of Planet Earth and Beyond" strands of the New Zealand Science Curriculum

Helping Them Pass
The use of formative assessment, trial exams and WebMCQ to assist students survive and excel in their first university exams.

Thomas C.T. Hubble[1] and James R. Dalziel[2]

School of Geosciences[1], and Department of Psychology[2] The University of Sydney

Overview

Formative assessment is a formal name given to the method of providing students with non-compulsory questions or tests in which the resulting marks not used for assessment. Ideally, student scores for these practice questions or tests are not even recorded by the teaching staff. This contrasts with more common assessment and test procedure, known as summative assessment, in which assignment or test marks do contribute to a student's course mark.

Answers given by students to sets of formative questions or tests are assessed according to the same criteria that would be used in summative questions or tests. Therefore the score they achieve is equivalent to a 'real' mark and accurately indicates the quality of the student's performance. Indeed, as far as a student is concerned the only difference, but the important difference, between a formative and a summative mark is that the formative mark is not seen by teaching staff. Hence the formative assessment method is an ideal way for students to ascertain their progress in a course without the risk of recording a poor score. The formative assessment indicates to the student their weaknesses and strengths without the anxiety and stress that often accompanies major assessment tasks.

Two other advantages of formative assessment are: a) students can be provided with the correct answer to a question which enables students to revise the course content efficiently; and b) students can develop an understanding of the level of complexity required of their answers by their instructors – this is especially the case with short essay or essay questions.

Two complimentary methods of formative assessment have been introduced into first year Geology and Engineering Geology classes at the University of Sydney. These consist of a trial exam program and sets of self-assessment questions presented over the Internet using the package WebMCQ.

The Trial Exam Program

Many students encounter difficulties making the transition from high school to university and adjusting to the much less supervised teaching environment of a university classroom (McInnis et al 1995). Experience and informal questioning of these students indicated that the first set of exams university students take are a significant hurdle. Geology 'freshers' were often unable to assess the level of difficulty presented by university exams as well as being poorly prepared for them. Many students indicated that they had used the 'past paper' preparation technique in preparing for their major high school exams and that they were very comfortable with this study technique. Some students complained that while past papers in geology were available, sets of correct answers for these past papers were not. Hence these students had no way to check whether their answers were right or wrong.

It was decided to introduce trial exams into all first year Geology classes at the University of Sydney in 1997. These courses are Engineering Geology One, Geology 1001 (first semester) and Geology 1002 (second semester) and the above information guided the development of the trial exams. They examine course content up to about week nine of the semester and are administered in week ten during practical class sessions. Trial papers have the same format and level of difficulty as the following end-of-semester exam but are only a third to half the length. Trials are marked and returned to students in week eleven. Those students with a mark less than 45% are informed that they are at serious risk of failing the semester one exams and are strongly encouraged to attend an exam assistance tutorial group. Students scoring between 45% and 55% are defined as being potentially at risk of failing and are also encouraged to attend the tutorials.

The tutorials that follow the trial exams deal with how questions in both the trial and previous exam papers should be answered. Specific difficulties or problems that students have can also be discussed in the tutes. Usually it is possible to schedule about ten hours of tutorial assistance for these students in the last two weeks of semester and the one-week study vacation that follows. About 25% to 35% of class members are eligible to attend such tutorial classes. Attendance at tutorials is usually about 15% to 20% of the whole class.

Class surveys indicate that the trial program is well received by students with around eighty percent of class members indicating that "the trial assisted them in preparing for their exams". Seventy-five percent of students indicate that being familiar with the exam format aids their exam preparation while seventy percent of students indicate that being familiar with the exam format reduces their anxiety about taking the end of semester exam.

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Overview

Formative assessment is a formal name given to the method of providing students with non-compulsory questions or tests in which the resulting marks not used for assessment. Ideally, student scores for these practice questions or tests are not even recorded by the teaching staff. This contrasts with more common assessment and test procedure, known as summative assessment, in which assignment or test marks do contribute to a student's course mark.

Answers given by students to sets of formative questions or tests are assessed according to the same criteria that would be used in summative questions or tests. Therefore the score they achieve is equivalent to a 'real' mark and accurately indicates the quality of the student's performance. Indeed, as far as a student is concerned the only difference, but the important difference, between a formative and a summative mark is that the formative mark is not seen by teaching staff. Hence the formative assessment method is an ideal way for students to ascertain their progress in a course without the risk of recording a poor score. The formative assessment indicates to the student their weaknesses and strengths without the anxiety and stress that often accompanies major assessment tasks.

Two other advantages of formative assessment are: a) students can be provided with the correct answer to a question which enables students to revise the course content efficiently; and b) students can develop an understanding of the level of complexity required of their answers by their instructors – this is especially the case with short essay or essay questions.

Two complimentary methods of formative assessment have been introduced into first year Geology and Engineering Geology classes at the University of Sydney. These consist of a trial exam program and sets of self-assessment questions presented over the Internet using the package WebMCQ.

The Trial Exam Program

Many students encounter difficulties making the transition from high school to university and adjusting to the much less supervised teaching environment of a university classroom (McInnis et al 1995). Experience and informal questioning of these students indicated that the first set of exams university students take are a significant hurdle. Geology 'freshers' were often unable to assess the level of difficulty presented by university exams as well as being poorly prepared for them. Many students indicated that they had used the 'past paper' preparation technique in preparing for their major high school exams and that they were very comfortable with this study technique. Some students complained that while past papers in geology were available, sets of correct answers for these past papers were not. Hence these students had no way to check whether their answers were right or wrong.

It was decided to introduce trial exams into all first year Geology classes at the University of Sydney in 1997. These courses are Engineering Geology One, Geology 1001 (first semester) and Geology 1002 (second semester) and the above information guided the development of the trial exams. They examine course content up to about week nine of the semester and are administered in week ten during practical class sessions. Trial papers have the same format and level of difficulty as the following end-of-semester exam but are only a third to half the length. Trials are marked and returned to students in week eleven. Those students with a mark less than 45% are informed that they are at serious risk of failing the semester one exams and are strongly encouraged to attend an exam assistance tutorial group. Students scoring between 45% and 55% are defined as being potentially at risk of failing and are also encouraged to attend the tutorials.

The tutorials that follow the trial exams deal with how questions in both the trial and previous exam papers should be answered. Specific difficulties or problems that students have can also be discussed in the tutes. Usually it is possible to schedule about ten hours of tutorial assistance for these students in the last two weeks of semester and the one-week study vacation that follows. About 25% to 35% of class members are eligible to attend such tutorial classes. Attendance at tutorials is usually about 15% to 20% of the whole class.

Class surveys indicate that the trial program is well received by students with around eighty percent of class members indicating that "the trial assisted them in preparing for their exams". Seventy-five percent of students indicate that being familiar with the exam format aids their exam preparation while seventy percent of students indicate that being familiar with the exam format reduces their anxiety about taking the end of semester exam.

It is not possible to definitively determine in a rigorous statistical sense, whether the trial program has raised first-year pass rates as there is no formal control group. Similarly, comparisons between different year groups are probably not valid. We suspect that more students are passing than otherwise would, (certainly most of the twenty percent of students who 'fail' the trial go on to pass their formal end-of-semester exams). But it may be that students are better prepared for their final exams because they have been exposed to an extra way of dealing with, and thinking about the course material.

To evaluate the effectiveness of the trial program we are left then with the positive student survey responses and the impressions of the course instructors who indicate that the students seem to be performing better in their end-of-semester exams. Teaching staff have also suggested that the quality of student answers to essay questions has improved. On balance it is our opinion that the trial exams have improved both pass rates and the performance of students in the first year geology courses.

Using WebMCQ in Geology Teaching

WebMCQ was initially designed to utilise the many natural advantages of the Web for providing "Web-based tutorials" to large classes (1000 students and more) taking the first-year Psychology program at the University of Sydney. By using the Web as the basis of this system, no paper resources are required, and students may use WebMCQ from any location with access to the Internet, such as classrooms, libraries, home and work. The system is interactive and platform-independent (i.e., it will run on any computer with Web access regardless of operating system, such as PC, Macs and Unix-based systems). Provision of such tutorial information is very flexible and students have used the WebMCQ materials at all hours of the day and night from wherever they have web access (Gazzard & Dalziel, 1997).

In formative mode, WebMCQ delivers immediate feedback on whether a student has answered each question correctly or incorrectly, and information regarding why each question option was correct or incorrect. Further, at the end of each initial feedback screen, a "more information" link is provided, which allows students to go to a further feedback screen which presents a general discussion of the question and the topic area to which the question was related. Students can download this information as a page of notes for ready reference at a later time. Students can then proceed to the next question from any of these feedback pages. Figure 1 illustrates the structure of the formative assessment system. Figure 2 shows a typical question and the first layer of feedback in the geological context.

Student Evaluations

WebMCQ was implemented for Engineering Geology One, in semester One 1999 and the student response has been very pleasing. Sixty-five of the eighty-five students who took the final exam used their USYD-ENGGEO1 site. During the two weeks before the exam each of these students used the site an average of five times and each student attempted all the questions available at least once. In each of the twenty-four hours before the exam the site was consistently busy with the minimum number of students using the site being five at three o'clock on the day of the exam. Students were still using the site in the computer access areas of the campus half-an-hour before the exam started.

In an evaluation survey Engineering Geology students were asked to give their WebMCQ a mark out of ten, 18% of the students gave it 10/10, 24% of the students gave it 9/10, 38% of students gave it 8/10, 13% of students gave it 7/10, the remaining student gave the site 5/10. In open questions that allow students to state what they found best and worst about the Engineering Geology WebMCQ site, and what they would change, students provided a wealth of comments about the project. All of these were very positive, and included "immediate feedback on answers", "Informative and thorough". "It emphasises your strengths and weaknesses". "Easy to use". "It was my only study method." and "It's fantastic."

As with the trial exam program it is difficult to measure the benefit to students of being able to access this type of material. Suffice it to say that only three students failed the course and two of these did not use the site. The site set up for Engineering Geology One at the University of Sydney can be visited at http://www.Webmcq.com through the user resources area. The name of the set is USYD-ENGGEO1, (the name is case specific). You should enter guest for both your name and password. Comments can be forwarded to tom@es.su.oz.au or tom@es.usyd.edu.au.

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World Wide Web, museums and schools - a case study from Norway

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The Paleontological Museum (PMO), University of Oslo contains the largest collection of fossils in Norway and functions as a National Museum. The museum consists of nearly 1.7 million fossils of which 700 are on exhibit.

By the mid-late 1990s the development of the world wide web (WWW) and other Internet services signalled a change in distribution of scientific and public data and information. Many education and museum institutions provided access to knowledge and exhibition resources. PMO established both homepage and email access by the end of 1994. In 1997 the usability of software and hardware had come to the point where museum staff could prepare complicated web pages and web based databases, and the PMO decided to make both collections and exhibitions available through the Internet.

For more than a decade PMO has developed expertise in using PC databases, initially dBase and in recent years Microsoft Visual FoxPro. All collection and exhibition data is entered into databases. The preparation of web pages was simplified as all information needed in web pages was already available in a database format.

Most of PMO's best specimens are on exhibit. Some museums choose to make special virtual exhibits of specimens not accessible to visitors, but we choosed the opposite, because of the large geographical distances in Norway. Our main target group was kids 6-15, and because of a new curriculum in Norway in 1997 project work and Internet use in schools are growing tremendously.
The project group comprised of museum scientists, students and designers. The work started with writing all texts used in the museum into Word and photographing every exhibit and specimen on display. All the pictures were then scanned and the texts were put into a database for processing. Introductionary pages were written specifically. These pages were simplified 3D images of the exhibition halls, making it possible for users to navigate to different showcases. The 3D images were prepared in order to make it possible for visitors (users) to recognise the real arrangement of showcases in case they wanted to visit the museum in person. The layout of the museum was followed on the pages, starting with an overview of the museum, then the showcase and finally the single fossil.

Themes

Larger themes of general interest like dinosaur extinction, mammoths in Norway, human evolution etc. are treated more in depth on special theme pages.

The type collection

The collection of types and illustrated material has a significant international scientific interest, and is curated according to international regulations. At present there are well over 19.000 type and figured specimens found in 960 publications dating from 1833 to the present. All relevant publications and specimens are recorded in the museum database and will be available on the www in the near future.

Experience so far

The pages are widely used by schools and by interpretation of the Internet log we are able to see how pupils use our site. We predicted that users would start on the introductory pages and go from general information towards more special information in the subject of interest. This was wrong, our logs tell us a very different story. The visitors appear on the page of interest, probably from search engines like AltaVista, not moving through our hierarchy of information at all.
A special "Ask a palaeontologist" page was prepared to obtain contact with the visitors and we recieve questions from pupils every day. There are no extensive books on palaeontology in Norwegian, and the museum has through the years acted as an information desk for visitors, school pupils and geology amateurs. The questions are e-mailed to two museum scientists, and most questions are answered within 2-5 days. We are now in the progress of making a FAQ (frequently asked questions) page with the most common questions and answers.

The "Pal-Web" pages are available in both Norwegian and English, and will be available from the museum shop on CD-ROMs.

Internet adresses:
Exhibitions, in Norwegian: http://www.toyen.uio.no/galleri/
Exhibitions, in English: http://www.toyen.uio.no/galleri/index_e.html
Type collection, text only: http://www.toyen.uio.no/typesaml.htm
Type collection, with pictures: http://www.toyen.uio.no/type_scann/
Home page: http://www.toyen.uio.no/

Teaching "Best Management Practices": New Emphasis on Old Problems of Contaminant Trespass

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While the petroleum industry still absorbs sizeable numbers of geoscience graduates, increasingly more are finding employment with State and Federal regulatory agencies or with private firms engaged in construction or environmental activities. Almost to a person, the new employees are surprised to learn that they are responsible for supervision, monitoring, or enforcement of rigid regulations that control the discharge of both storm water and municipal and industrial waste water. In the United States, these regulations rely heavily on what are termed "Best Management Practices" (BMP's). BMP's are the "law of the land" and the term, basically, refers to: "any and all methods for controlling the *quantity* and *quality* of storm water runoff"(USEPA, 1990). Thus, BMP's are considered as either: (1) a practice, or procedure, that reduces pollutants available for transport *before* they are carried off from a site by normal runoff from rainfall events or (2) a device that reduces the amount of pollutants *in* the runoff, but before it is discharged to a surface water body. The latter typically include silt fences, hay bales, retention ponds, check dams, gravel filters, rip-rap, vegetative controls, and berms and swales used to reduce the quantities of sediment-laden waters that are leaving a site. While exposure to the techniques and importance of BMP's in engineering schools is common, it is not at all unusual to encounter earth scientists for whom the term is completely foreign. Little mention of these practices will be found in most secondary school earth science courses, and the same is true in most colleges and universities. The

rationale for controlling egress of water is clear and arises from the fact that a number of different types of pollutants are typically found in urban runoff, all of which may have adverse effects on bodies of water into which they flow downstream. It is therefore important to impress upon students that the net effect of urbanization is *always* to increase pollutant runoff loads, usually by at least one order of magnitude, and thus steps must always be taken to minimize any downstream impact. The consequence of runoff are seen not only in immediately adjacent streams and lakes, but also on all water bodies downstream. Typically, runoff pollutants may include:

(1) *Sediment* - which causes increased turbidity, reduced light penetration, reduced prey capture for sight-feeding predators, smothering of the benthic community and other negative effects on the biota.

(2) *Oxygen Demanding Substances* - decomposition of organic matter by microorganisms depletes dissolved oxygen, especially in slower moving streams and lakes, resulting in deleterious effects on the biota.

(3) *Nutrients* - excess quantities of nitro-gen, potassium, and especially phosphorus, can lead to eutrophication in downstream re-ceiving waters. This can produce dense growths of green algae and ultimately, water discoloration, noticeable odors and loss of oxygen as the algae decompose.

(4) *Heavy Metals* - these are of particular concern because they may be toxic to aquatic life and have the potential of contaminating drinking water. Those present in highest concentrations in urban runoff are copper, lead, and zinc with cadmium a distant fourth (USEPA, 1990).

(5) *Bacteria* - levels of fecal coliform present in urban runoff invariably will exceed those deemed acceptable by Public Health agencies. Further, bacteria may show a many-fold difference in concentration levels from summer to winter, even in the absence of known sources of contamination In the absence of contamination from known sanitary sewage, the health implications of excess levels of bacteria are imperfectly known. Current literature suggests that fecal coliform may not be useful to identify health risks from urban runoff pollution.

(6) *Other Pollutants* - include substances such as oil and grease and various toxic chemicals. The former can be a problem because hydrocarbons have a strong affinity for sediments and tend to accumulate rapidly in lakes and estuaries where they may exert adverse effects on benthic organisms. Toxic chemicals, in contrast, are rarely found to exceed water quality standards. Obviously, local exceptions to this may exist.

BMP's, thus, are directed toward minimizing the effects of runoff from one site to another and, ultimately, toward protecting and lessening the impact that urban, industrial, and agricultural pollutants have on down-stream water bodies. To a large degree, the implementation and enforcement of the use of BMP's in the United States to control pollutants stems from the 1987 amendment to the Clean Water Act, promulgated to restore and maintain the Nation's water quality. All municipal and industrial entities discharging wastewater must now acquire a National Pollutant Discharge Elimination System (NPDES) permit before release of any effluent is allowed. These permits are issued by the U.S. Environmental Protection Agency (USEPA) and reflect a heavy reliance on BMP's at each site to reduce pollutant loadings and improve water quality. In 1992, this requirement was extended to all construction sites that disturb greater than 5 acres of land. Individual States in the U.S. are further empowered to place even more stringent restrictions on such activities and the NPDES permit issued will reflect both Federal and State limits on the discharge allowed. These permits must also be renewed periodically and greater restrictions (or exceptions) are made on an individual basis only. Hence, there is not only enforcement of regulations carried out at the National level, but also enforcement at State (and Local) levels. Consequently, many new graduates find themselves having to determine whether or not a particular industry, municipal operation, or construction site is in compliance with conditions stated in its NPDES permit. While the classic geology curriculum that includes courses in mineralogy, petrology, structural geology, paleontology, sedimentation, stratigraphy, etc. may serve the student well for employment as a petroleum geologist, those seeking employment with Federal and State regulatory agencies, and those working with engineering and environmental firms are at a severe disadvantage if they lack course work in environmental geology, hydrology, geochemistry, and statistics. Too many students now graduate without even a cursory knowledge of organic chemistry. In years past, courses in organic chemistry were eschewed, in favor of physical chemistry, which was deemed more important. The reverse is now true for those employed by regulatory agencies. Similarly, many students have been exposed to statistics only to the degree to make them "dangerous." This, because they have no comprehension of when to apply parametric versus non-parametric statistical tests (or, in many cases, do not even know that appropriate non-parametric test exist) or that in many cases, multivariate procedures are the methods of choice. The USEPA has strict protocols that use both parametric (when appropriate) and non-parametric tests to determine whether a site is in compliance with regulations. In recent years this agency has raised strong criticisms that recent geoscience graduates lack critical fundamental training in statistical analysis. Consequently, students should be urged to enroll in a minimum of two courses in statistics. The reason is simply that in a single semester course, little more can be covered other than the measures of central tendency, measures of dispersion, central limit theorem, correlation, and (perhaps) regression. The use of t-tests and analysis of variance (and their non-parametric equivalents) are beyond the scope of a first semester course, yet are of critically important for today's geoscience graduates. Awareness of the modern day dependence on statistical analysis should be impressed on earth science students in secondary schools, and again early in their college careers so that they will have the opportunity to acquire such instruction. A second problem results from the fact that even within the "classic" earth science college curriculum, little time is spent providing the student with the type of training that will allow them to appreciate the importance of BMP's and, following graduation, to determine whether violations of BMP's are (or have) taken place at any given site. As an example, many students, either as undergraduates or as graduate students, complete courses in sedimentation or sedimentary petrology. Rarely in these courses, however, is any time spent to provide instruction in the use of sediment mineralogy to "fingerprint" the source of sediment. One of the most prevalent violations of BMP's involves "sediment trespass." Because confirmation of sediment trespass may result either in a fine being levied at those responsible for the infraction, or may be the basis for a damage suit in a court of law, allegations of sediment trespass are often strongly contested by those accused. It is frequently possible, however, to *prove* that such trespass has taken place (and, therefore, that BMP regulations have been violated) by showing that non-indigenous fill material used at a construction site has been carried off site by storm water. This can be accomplished by simple comparison of the heavy minerals in the sediments at the construction site versus those in the off-site sediments where trespass has taken place. The similar use of clay minerals (as determined from X-ray diffraction analysis) can also be used for this purpose. While such applications may be obvious to the instructors, they are often not passed onto their students. Hence, many graduate unaware that straight-forward, useful techniques for establishing violations of BMP's are available.

Enforcement of BMP's (if one works for a regulatory agency) or being able to assure management that BMP's are being followed is thus a commonplace task for today's geoscientist. Such responsibilities represent a marked change from the tasks assigned geologists in the past but as times have changed, so have the skills that are now necessary for the profession. More than half of the States in the U.S. now require practicing geologists to be licensed. Acquisition of the license requires the applicant to take a formal exam and to provide evidence of a B.S., M.S, or Ph.D degree in geology. and documented post-graduation experience. All States now requiring the exam include questions that require an understanding of BMP's. Failure of many geoscience departments to include instruction in BMP's as part of the curriculum therefore places the graduating student at a distinct disadvantage.

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Earth Science Week and Other Means for Raising Science Literacy

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In a growing number of countries and communities, the Earth sciences are center stage each year during Earth Science Week as schools, libraries, nature centers, museums, and geoscience organizations focus attention on the contributions the Earth sciences bring to our daily lives. Earth Science Week is celebrated annually during the second week of October. The American Geological Institute (AGI), a federation of 34 professional geoscience societies, launched Earth Science Week in the United States in 1998 as a special 50^{th} anniversary outreach initiative. This high-profile annual event is creating an unprecedented opportunity for the geoscience community worldwide to raise public awareness and understanding of the importance of the Earth sciences.

Earth Science Week is one of the major components of the American Geological Institute's outreach program. The Institute's public education and outreach objective is to implement an effective program that will strengthen the image of the geosciences and to position them strategically in the public consciousness. The Institute is developing a multifacted public education and outreach program around the following components.

Earth Science Week — Creating a national focal point each October

Earth Science World — Creating a global focal point on the World Wide Web

Inside Science — Increasing TV news coverage of the Earth sciences

Environmental Awareness Series — Providing the geoscience context for topics of environmental concern

Earth Science Week

Earth Science Week '98, October 11-17, was widely recognized in the United States. More than 15,000 geoscientists, teachers, librarians, naturalists, museum curators, and scout leaders participated in Earth Science Week in their communities. The governors of 39 states and several city mayors issued Earth Science Week proclamations. In July, Senator Ron Wyden of Oregon read an Earth Science Week statement and resolution into the Congressional

Record, and on October 9, President Clinton signed an Earth Science Week message encouraging all citizens to participate. Throughout the country, the AGI member societies, other geoscience and educational organizations, college and university departments, museums, nature centers, state geological surveys, and Federal agencies sponsored Earth Science Week events and activities.

By Earth Science Week '99, October 10-16, U.S. programs had expanded and evolved and international interest had grown dramatically. In a number of states and communities geoscientists have developed ongoing programs and mechanisms to increase the Earth-science presence throughout the year. Geoscientists in Arizona, Idaho, and Texas have been especially effective in extending the impact of Earth Science Week. During Earth Science Week in Austin, Texas, for example, several bookstores sponsored an Earth-science book drive to improve local library collections. In Dallas, Texas, the Education Committee of the Dallas Geological Society launched a program during Earth Science Week to work with teachers and students in 18 schools, and they are continuing the program through the school year. Beyond the United States, geoscientists and geoscience organizations in Argentina, Australia, Canada, Colombia, Croatia, Germany, Hong Kong, India, Japan, Liberia, Malaysia, Mexico, New Zealand, Norway, Poland, Puerto Rico, Saudi Arabia, Scotland, South Africa, Spain, Switzerland, Taiwan, and Trinidad planned local Earth Science Week activities.

To promote participation in Earth Science Week, AGI places articles and distributes educational posters in the leading publications for science teachers and geoscientists and maintains the Earth Science Week web site, http://www.earthsciweek.org. AGI also provides an Earth Science Week information kit, which contains an assortment of educational materials, upon request.

Earth Science World

The majority of visitors to the Earth Science Week web site are members of the general public who interested in the Earth sciences or have a reason to need Earth science information. As a result of this demonstrated interest and the public's need for scientific information that is both credible and understandable, AGI has developed the concept for a cooperative online center for Earth science information called Earth Science World. The Earth Science World web site will be the year-round presence of Earth Science Week. The interactive site will be engaging, educational, and entertaining; it can become best place online to discover and explore the world of the Earth sciences. Visitors to the site will be able to monitor geoscience events, such as earthquakes and volcanic eruptions throughout the world. They will be able to drill a virtual oil well, prospect for minerals and develop a virtual mine, hunt for virtual fossils, and gain an understanding of geoscience environmental considerations. They will be able to get Earth science news and information, browse the Earth science bookstore, obtain student activities and teacher guidelines geared to the National Science Education Standards, ask questions of Earth scientists, work puzzles, play games, and take virtual field trips and online courses. The Earth Science World site has enormous potential for public education and for strengthening the image of geoscientists and the geosciences. As it maintains the Earth Science Week web site, AGI is laying the foundation for Earth Science World by developing a prototype and working relationships with content partners.

Inside Science

In each 2-3-minute TV news story, Inside Science graphically highlights the science and scientists behind today's news. The American Institute of Physics (AIP) produces these lively science "news-you-can-use" stories, which are distributed weekly to participating television stations. Each story is ready-to-air and comes with narrated and non-narrated versions and a script.

Support from the U.S. Geological Survey enabled AGI to participate in the Inside Science program and to produce five news stories as a pilot project in 1998-99. In October 1998, AGI coordinated its first Inside Science piece, a 2:10 minute story on declining oil and gas reserves, "Are We Heading for an Oil Crisis?". The story was aired by NBC affiliates in 10 markets including Philadelphia, the 4th largest market in the country. AGI's second Inside Science piece, "Weathering Ferocious Winds," was released in November. Preliminary data from Nielsen Media Research show that the Wind story was aired by 40 NBC, CBS, and ABC affiliates reaching a potential audience of 5.1 million viewers. Statistics to date for the December story, "Tracking Groundwater Contamination," show that the story was aired by 44 stations reaching 2.1 million viewers. "Warnings in the Ice," a story on ice-core research and climate studies which was released in January, was aired by 16 stations reaching 1.2 million viewers. The final story in the pilot program, "Unlocking the Secrets of the Sea," a feature on coastal erosion was released in February.

The American Institute of Physics hopes to expand the coverage and frequency of the Inside Science series, and the American Geological Institute is seeking support to continue its participation in this effective outreach medium.

AGI Environmental Awareness Series

The Environmental Awareness Series provides dynamic booklets and engaging posters on topics of environmental concern. The booklets present material in its geoscience context, and they are designed especially for students and citizens with little or no background in science. Each poster includes an educational investigation as well as background information. The posters are widely distributed to students, teachers, youth leaders, and geoscientists.

The objective of the series is to raise public awareness and understanding of society's complex relationship with the Earth and its resources and to help readers develop geoscience-based understanding of environmental and resource topics. As part of the Series, AGI has published two 64-page booklets, Sustaining Our Soils and Society and Metal Mining and the Environment,two posters, "Soils Sustain Life," and "Metals Empower Us," as well as a colorful and "useful" soils bookmark with a grain-scale chart on the back. AGI produces the Environmental Awareness Series in cooperation with member societies and geoscience agencies and with support from the AGI Foundation.

The Environmental Awareness Series dovetails nicely with AGI's Earth Science Week effort. Ancillary materials such as posters and bookmarks are important educational components of the Earth Science Week information kit.

Raising Science Literacy

Although each component of the American Geological Institute's public education and outreach program has great potential to increase awareness and understanding of the Earth sciences, the real key to raising science literacy is to work collectively to increase the impact of Earth science outreach activities throughout the world.

Geosciences for National Development and Education; Challenges for the Department of Geology, Eduardo Mondlane University, Mozambique

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The Department of Geology (DG), Eduardo Mondlane University (UEM) is the single geoscience higher education and research institution in Mozambique and was founded in 1963. Teaching of Geology at UEM was interrupted from 1980-1985, when it re-opened as part of the national effort to build up Eduardo Mondlane University as a national centre for Tertiary sector education and research meeting all societal needs in the newly independent Mozambique. Presently, the DG, part of the Faculty of Sciences, comprises academic (3 PhD's and 6 MSc's) and technical staff members (8), annual student intake of 25-30 students, educational facilities (5 classrooms, audiovisual equipment, computers and software, a library with more than 4000 books, a museum, etc.) and analytical equipment (sample preparation, sedimentology, X-ray, AAS, microscopes, some geophysical equipment, etc.). The DG offers a five-year "Licentiatura" program that includes courses in all major geoscience subjects, analytical practice, extensive fieldwork periods and a final-year research assignment.

During the coming decade the DG aims to further develop its capacity in teaching, research and public education. The following aspects are some of the efforts carried out to reach this:

- ongoing PhD research projects for DG staff with several international counterpart institutions, for further developing in-house research specialisations, relevant for Mozambique. In addition, the DG participates in several international research programs.
- ongoing development of courses and course materials with use of state-of-the-art computer equipment and teaching materials (interactive CD-ROM, reference libraries). The DG covers most of the Geology curriculum and also contributes to courses for other Departments at UEM.
- a Geological Museum exhibits national and international mineralogical, petrological and palaeontological collections. Increasingly, it will play a role in public education for geoscience and

environmental issues (natural resources & hazards, small-scale mining, high school outreach programs in geography and environmental classes).

A co-operation project between the Eduardo Mondlane University-DG and the Faculty of Earth Sciences, Utrecht University (UU), The Netherlands, focuses presently on the strengthening of the 5-year geosciences curriculum with:

- highly qualified teaching and research capacities in core geoscience subjects
- special attention to applied geology & exploration, sedimentology, structural geology, and petrology
- the development of new expertise (in engineering & environmental geology)
- appropriate laboratory, educational and fieldwork facilities
- regional co-operation (South Africa, Zimbabwe, and Tanzania) for education, joint research and expert missions (regional & economic geology, geomorphology, geotectonics)

In the Southern Africa region a regional network of co-operating Earth Science Departments is developing. DG-UEM has excellent co-operation with Zimbabwe, South Africa (UCT, Cape Town, and Univ. of Natal, Durban) and Tanzania. Aims are to jointly develop and exchange complementary expertise for specialised geoscience courses, operate specific analytical facilities (joint use), co-operate in cross-border and mutually relevant research programs, and share expertise for public awareness programs and geoscience policy development. A regional Workshop to further develop this regional network and address the mentioned objectives is planned for 2000 in Maputo, Mozambique.

Besides these contacts at regional level, DG is discussing co-operation with higher education institutions of other countries outside the region. Thus, a research project on the geology of N-Mozambique is being developed with Naples University (Italy); the establishment of a coal laboratory is being discussed with Newcastle University (Australia); there are tight contacts with Aveiro University (Portugal) for co-operation in research, education and training.

In summary, DG is strengthening its in-house teaching and research capacities in order to offer proper services to a growing national and to a more integrative regional demand. DG foresees the first decade of the new millennium not only as challenging, but also full of expectation

Earth System Science Education: An Interdisciplinary Approach

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USA

Earth System Science

Earth system science views the Earth as a synergistic physical system of interrelated phenomena, governed by complex processes involving the geosphere, atmosphere, hydrosphere and. biosphere. Fundamental to the Earth system science approach is the need to emphasize relevant interactions of chemical, physical, biological and dynamical processes that extend over spatial scales from microns to the size of planetary orbits, and over time scales of milliseconds to billions of years. In building on the traditional disciplines to study the Earth, the system approach has become widely accepted as a framework from which to pose disciplinary and interdisciplinary questions in relationship to humankind. Earth system science forms the foundation of NASA's Earth science vision as well as the basis of the NSF geoscience long range planning effort as part of the nation's global change research objectives.

Within the concept of the Earth as a complex and dynamic entity involving the disciplinary spheres for land, air, water and life, there is no process or phenomenon that occurs in complete isolation from other elements of the system. While this system view is elegant and satisfying philosophically, the challenge to researchers and educators attempting to quantify the breadth of the system's elements, states and processes within the classroom is enormous. No individual, academic department or university is capable of developing and offering the enormous depth and breadth of knowledge such a paradigm demands. Only by joining faculty from different disciplines within and among universities can the diversity and complexity of Earth system science be fully appreciated.

The challenge for educators to develop and offer courses in the classroom that provide this deeper understanding is demanding. Earth system science seeks to construct an overarching interdisciplinary framework of process and state of the system, and at the same time retain the strength of traditional disciplines for understanding fundamentals and complex interactions. Colleges and universities have been attracted by this holistic approach to studying the Earth and adopt Earth system science as a theme. In developing and offering introductory and advanced courses which are relevant to the broader interests of faculty and students, the challenge is to provide the necessary depth and breadth needed to serve as a foundation for advanced study among majors, and lay the foundations for sustainability and informed stewardship in striving for an Earth-aware society.

The ESSE Program

As Earth system science emerged as a framework for addressing the scientific dimensions of global change, NASA, the Universities Space Research Association (USRA) and university scientists concluded that mechanisms were urgently needed to stimulate collaboration among scientists and departments within universities, among universities, and between university and government science centers. As a result of those discussions, USRA formulated the Cooperative University-based Earth System Science Education (ESSE) concept that created a university-based cooperative effort in Earth science curriculum development and interdisciplinary course offerings. The framework was designed to overcome traditional barriers and foster interdisciplinary science education.

Twenty-two US universities were selected in 1991 to participate in the original ESSE program. In 1995, the program was extended to bring an additional 22 colleges and universities into the program through the year 2000. This second phase of ESSE extends the emphasis of the program across the broader interests of global change by including disciplinary interests from the intersection of human dimensions with the climate system. Thousands of students are enrolled in ESSE courses each year, with over 100 faculty and teaching assistants directly involved.

ESSE emphasizes classroom education, collaboration, a network of faculty and students focused on the scientific and human dimensions of global change, and a shared repository of teaching resources. ESSE participants design and offer survey and senior level courses on Earth system science topics. A scientist/faculty exchange component of the program brings to the classroom expertise and perspectives different from those at the host campus. Sharing of materials is accomplished via the ESSE web site [http://www.usra.edu/esse/essonline]. An electronic list server focusing on the interests of the broader Earth system science and global change education community has also been established as a forum for discussion of relevant topics and questions for the participants. Hands-on workshops and tutorials are held each year for faculty and teaching assistants to exchange and develop content and familiarize participants with new software tools and methods for the classroom. An overarching objective of ESSE is to develop interdisciplinary courses and topical modules for the classroom through collaboration among universities and other partners.

Learning Modules

ESSE participants have identified a series of 14 interdisciplinary topics as the basis for the creation of "learning modules" (see the ESSE web site). Topics were purposely selected to cross disciplinary boundaries and offer an integrated perspective of ESS. A module subtopic, or submodule, is populated with resources or instructional materials designed to impart specific concepts or skills. Each topical module is a collection of individual submodules that can stand alone for use in the classroom or laboratory for explaining key concepts, or be used in consort with other submodules to support a larger effort in ESS education. The use of the submodules is determined by the instructor, with the aim of producing content in distinct self-contained increments so as to find use among a wide potential audience.

ESSE participants are in various stages of developing these modules, and testing their effectiveness in a classroom situation. An effort to focus on modules that are already under development, either as part of the formal ESSE activity or in partnership with others, striving to ensure robust content, functionality and inter-module coherence is being planned. An iterative process of building, testing, and revision based on user experience within classrooms of different universities will assure that the project produces quality educational resources.

Peer Review

To assist with the formal quality control and recognition of Earth system science learning resources, ESSE has proposed a peer reviewed online Journal of Earth System Science Education (JESSE) for the purpose of creating a common repository of quality Earth system science education resources for undergraduate and graduate classroom instruction. JESSE peer review will offer to the authors of these materials the recognition deserved for their commitment to education, and may assist in institutional reward and tenure decisions. An editorial/advisory board has been established to refine and implement the review process and establish review criteria, including content accuracy, pedagogical effectiveness and presentation format/ease of use. Provided that financial support is forthcoming, an innovative and open peer review process will be implemented, encouraging reviewer-developer communication, with provision for confidential exchange. Final reviewer attribution will be on open record to optimize commentary and exchange among authors and users.

Summary

Several outcomes have emerged from the ESSE Program that are evident from the direct faculty involvement in the Program. The offering of courses and development of content for Earth system science requires genuine collaboration, sharing knowledge across disciplines and exploring together those aspects of the system which reside between traditional disciplinary boundaries. A community of several hundred faculty, lecturers and teaching assistants who are directly involved in Earth system science classroom education within the United States, Canada, Central and South America has been established. In so doing a coordinated interdisciplinary partnership of institutions and individuals is developing the breadth and depth of scientific knowledge required for offering the course content of Earth system science in the classroom with an emphasis on the Earth as a natural resource to sustain humanity.

Cyclic Thinking as Applied to the Rock Cycle

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The rock cycle, a topic included in the new learning program "Science and technology" for Junior High schools, requires systematic/cyclic thinking abilities. In order to be able to "read" the processes "written" on the materials of the earth: rocks, minerals and soils, students are required to understand the different processes which take place within the earth. They must also be acquainted with the starting and ending products of each of these processes, and understand that each end-product of one process can be a starting-product for another process. Such systematic thinking requires constant organization of knowledge. One of the most common methods for organizing knowledge is by constructing concept maps.

Are Junior High school students able to grasp this kind of thinking? Can the construction of concept maps with the aid of the computer software "KnoW" produce such comprehension? Can students develop a general ability, which can be called "systematic thinking ability"?

In our talk we will present preliminary data that will put light on these questions.

The New Paradigm on Teaching Method of Environmental Geology in Indonesia

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Environmental Geology is an applied Geoscience which takes up a systematic study of the natural processes without which environmental problems can be neither understood nor solved.
In Indonesia where there are highly potential natural resources as well as geological hazards, the Environmental Geology has an important role to optimize such resources and minimize the impact of such hazards. Geological Engineering Department in Gadjah Mada University has strong commitment in participating toward continuous quality improvement of living environment on the earth by always improving methods of exploration and exploitation of natural resources to optimize benefits and minimize waste, pollution, and risks. That is why Environmental Geology has been established as a compulsory subject in this Department.

Rationale

Environmental problem is commonly complex and controlled by the integration of several environmental components, i.e. the physical, biological, as well as socio-economical components. Thus it should be solved by an integrated assessment on all of those controlling components.

Accordingly, the environmental geologists which are capable to integrate their knowledge and skill to the other disciplines are required. Indeed, the communication skill and ability to co-operate with the other experts, stake-holders and public are crucial for them.

Furthermore, the environmental geologists should also be sensitive to react to the environmental issues, in particular those related to the environmental geological problems. Therefore, it is apparent that the teaching method in Environmental Geology should be able to produce the graduate with such qualifications. Indeed, the Engineering Geology subject should be focussed not only on the content aspect (syllabi) but also the methodological aspect. Those were not accommodated appropriately by the old paradigm in Teaching Method. Such method only emphasized on the content aspect by assuming that the student heads as an empty vessels. The teacher acted as an instructor, thus only one way communication was proceeded with much more teacher presentation than student activity.

Goal and Objectives

The goal of the new paradigm in the proposed teaching method is to improve the competencies of graduates in the subject of Environmental Geology by introducing more interactive and communicative teaching method. The specific objectives are to :

- improve the student understanding on the role and importance of Environmental Geology,
- improve the student awareness to the environmental issues,
- motivate and stimulate student creativity in applying the environmental geology to the real problem,
- improve the student capability to communicate, cooperate and interact with the stake-holders dealing with the environmental problems,
- improve the student willingness to campaign for environmental protection.

Strategy

To achieve the stated goal and objectives the lecturing strategy can be formulated as follows :

- Both content and methodological aspect of lecturing will be given equally.
- The students are considered as participants, which will be the subject in the learning process and thus two way communication can be conducted.
- The students (participants) are assumed to have had some experience (knowledge) in advance.
- Learning process will be proceeded more by practicing rather than by the lecture talks or theory presentation.

Syllabii

The syllabi had been improved by adapting with the current environmental issues. These include :

- Understanding the concept and importance of Environmental Geology (1 session).
- Understanding the concept of Sustainable Development (1 session game and 1 session lecture presentation and discussion)
- Discussion on Agenda 21 and how this is applied in the local regions in Indonesia (1 session).
- Presentation and discussion on how to manage Natural Resources (Geological Resources) with respect to the sustainable development and Agenda 21 (4 sessions).
- Presentation and discussion on how to manage/ anticipate Geological Hazards (4 sessions).
- Presentation and Discussion on Environmental Impact Assessment and Environmental Audit (2 sessions).
- Resume of all topics (1 session)

Therefore each semester there are 15 sessions, given once per week for 100 minutes per session. The field work and institutional visits are carried out once a month, in additional to the session meeting in the class.

Pre-requisite

The participants who are eligible to participate in this lecture are those who have participated in some pre-requisite lectures as follows : Geomorphology, Petrology, Stratigraphy, Structural Geology, Hydrogeology, Volcanology, Engineering Geology, and Economical Geology.

Teaching Method

The methodology introduced can be described as follows :

- the module (outline of the lecture contents) together with the syllabi and the bibliography should have been distributed to the participants prior to the lecturing,
- introduction test is conducted to evaluate the initial level of student knowledge on environmental geology,
- the lecturing is proceeded by two ways (interactive) communication,
- the lecturer acts as a facilitator/ moderator,
- case studies which rely on the real environmental problems in field are provided,
- in each session in the class the lecturer explains only the main idea of a specific topic for less than 20 minutes (each session is run in 100 minutes), and then a case study is introduced,
- in each session the participants should have more chance to work out with the case studies and discussion,
- field excursion related to the case studies are also conducted,
- institutional visits to the stake holders dealing with environmental problems are conducted as well.

By applying this method not only the participants' understanding but also the creativity, communication skill and ability to cooperate can be improved.

Consequences

In order to carry out the education process effectively the big class size (80 participants more) should be managed as below :

- the class should be separated into two parallel class, consisting about 40 participants each class.
- each class should be separated into several smaller working groups where each group is responsible for one case study/ tasks in each session. Each group consisting of about 8 participants.
- the teaching team consisting of at least 2 lecturers and 5 assistants is required for the two parallel classes. Each assistant will be responsible for two working groups.

Some supporting facilities are also required as a consequence of the method introduced. Those includes :

- references, such as textbooks, journals, project reports, newspaper etc.
- photo slides on environmental problems
- video film / CD ROM concerning with environmental issues
- internet facility

The links with other faculties as well as the Center for Environmental Studies in Gadjah Mada University and other environmental institutions at national and international levels should be established to support the success of this education program. So far, the Geological Engineering Department at Gadjah Mada University has established such links to the Civil Engineering Department and Faculty of Geography at Gadjah Mada University, and also to the Department of Civil Engineering at Tokyo University of Agriculture and Technology; Department of Civil Engineering, Yamanashi University Japan; Dept of Earth Sciences, Leeds University, the United Kingdom; the Natural Hazard Research Centre Macquarie University, Sydney, Australia; German Foundation for International Development, Germany; The Directorate General of Environmental Geology Management, Indonesia; Research Center for River and Sabo, Ministry of Public Works Indonesia.

Evaluation

The student and facilitator performance and understanding will be evaluated by:

- evaluating student activities in the discussion and in the case study, field work and institutional visits,
- evaluating the product (report) of case study,
- conducting self-evaluation by both student and facilitator,
- conducting feedback evaluation.

Several aspects that should be evaluated in self-evaluation and feedback evaluation are:

- the syllabi, as well as the structure and contents of module,
- the relevance of the syllabi and module to the real problem in field,
- the lecturing method,
- the lecturing process,
- the style and skill of lecturer/ assistant as facilitator,
- the level of participants' understanding after participating the sessions,
- the mood conditions of both facilitator and participants during the session/ meeting,

- the quality and effectiveness of supporting facilities,

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GEOSCAPE TORONTO - A Geoscience Public Awareness Project

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The Greater Toronto Area (GTA), including the City of Toronto, is Canada's largest and most rapidly expanding urban centre. Located on the glaciated north shore of Lake Ontario, where waters from the vast Great Lakes watershed gather on their way to the St. Lawrence River, the GTA is home to almost 5 million people. In order to promote a broader awareness and deeper understanding of the array of geological features and issues that affect the GTA and its burgeoning population, a team of geologists, geographers, environmental specialists, Earth science educators, geotechnical engineers and land-use planners is developing a new geoscience education initiative entitled GEOSCAPE *TORONTO*. Modeled after the highly successful GEOSCAPE *VANCOUVER* pilot project, the core of GEOSCAPE *TORONTO* will be a colourful poster with thematic topics arranged around a central map. Extensive graphic components will be designed to engage, involve, and educate by revealing the critical connections between geoscience and the expanding mega-city. Issues relevant to everyday life in a major urban centre, such as water supply and quality, waste disposal, transportation, land use, access to building materials, and natural hazards, will be examined in the context of the local and regional geological setting. GEOSCAPE *TORONTO* will demonstrate how knowledge of dynamic Earth processes, local geological history, and Earth materials is essential in informed decision-making about the wise use and responsible management of land and water, and in more rationally evaluating the complex resource and environmental conflicts within the GTA.

The primary target audience for GEOSCAPE *TORONTO* will be students in general, but with a particular focus on those between approximately 12 and 17 years of age (representing grades 7, 9, 11 corresponding to specific sections of the new Ontario science curriculum). It is also intended that GEOSCAPE *TORONTO* should become an important information source for municipal governments, urban planners, naturalists, industry, and the general public.

GEOSCAPE *TORONTO* is being developed under the leadership of the Geological Survey of Canada with advice and guidance from the GSC staff who created the original GEOSCAPE *VANCOUVER* model. Project partners currently include, among others, representatives of the University of Toronto (Department of Geology), the Geological Survey of Canada, the Ontario Ministry of Northern Development and Mines (Ontario Geological Survey), the Royal Ontario Museum, the Prospectors and Developers Association of Canada (Mining Matters), the Ontario Ministry of Energy, Science and Technology, and the Canadian Geoscience Education Network of the Canadian Geoscience Council. To ensure adequate coverage and to strengthen content in the initial development phase, theme planning sessions have included additional representatives of the broader geoscience sector. Through an open comment page on the GEOSCAPE *TORONTO* website, the core team is also seeking active input from the wider public (educators and students, industry, governments and their agencies, conservation authorities, and learned societies) in choosing and developing specific poster themes. Much of the development work will continue to be done on a voluntary basis by interested geoscientists and educators in the community. Supporting funds for technical assistance, graphic design, drafting, for printing costs as the poster moves into the production phase, and for publicity, will be solicited from organizations with strong interests in promoting geoscience education.

The GEOSCAPE *TORONTO* poster is planned for release in the year 2000. Through a commitment to maintaining the website, the Geological Survey of Canada is ensuring an active 10-year shelf-life for the project. Associated materials designed to illustrate and expand on the various thematic components of GEOSCAPE *TORONTO* will become available separately via the website, website links, or as hardcopy posters, slide sets, and web-CDs. Additional resources, such as field trip guides, study outlines, and references will also be featured on the website as they are developed.

Websites:
GEOSCAPE *TORONTO*
<www.toronto.geoscape.org>
GEOSCAPE *VANCOUVER*
<www.vancouver.geoscape.org>

Teaching the Dynamic Earth: an exciting new venture involving In Service Education for Teachers

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Background

All schools in England and Wales are required to provide opportunities for In Service Training (INSET) for their staff at intervals throughout the school year. Financial constraints mean that schools mostly run their own sessions, rather than bring in external consultants. Science staff readily admit that they mostly lack sufficient expertise in Earth Science to feel comfortable in teaching the Earth Science components of the National Science Curriculum in England and Wales. They feel even less competent to train their school colleagues in Earth science principles and techniques, so the subject is frequently given a very low priority.

Thanks to recent funding from the UK Offshore Operators' Association (UKOOA), it has been possible to set up the Earth Science Education Unit, under the auspices of Keele University. The Unit consists of three people, all offering part-time service to the Unit, who take INSET to schools within reach of their homes, at minimal cost (i.e. travel and incidental expenses only). The INSET programme is running as a pilot scheme for the year 1999/2000 in the first instance.

At the time of writing this abstract, the Unit has only just begun its operations, but by the time of the Conference there will be a developing story to tell.

Content of the project

The needs of schools vary considerably and the Unit is alert to the danger of teaching people what they know already. We are therefore offering an "a la carte menu" of topics, from which schools are invited to select what they most require and which will fit the timings of their training day or half-day.

Details of the different workshops offered are as follows:

1. Experience of practical/investigative work at Key Stage 3 (11-14) - 1 hour

A series of practical activities is laid out in the lab and teachers are invited to try them out. A quick tour of the experiments at the end of the session enables teachers to explain what they have been doing and to evaluate the usefulness of the activities in lessons.

2. The plate tectonics interactive at Key Stage 4 (14-16) - 2 hours

How to teach plate tectonics and the structure of the Earth in an interactive way. How to build on the basic understanding that pupils bring with them from KS3 geography courses. How to provide scientific explanations for a dynamic Earth on a global scale. The rationale for this topic and the approach will be explained by Chris King at this Conference.

3. The dynamic rock cycle at Key Stage 4 (14-16) - 2 hours

How the rock cycle may be used to organise schemes of work at KS4. The session shows how the major geological processes may be taught through a range of practical and investigative lab activities.

4. Earth science evidence and time at Key Stage 3 or 4 (11 to 16) - 1 hour

How to use evidence from rocks like a rock detective to sort out time sequences, paint a picture of the past and "solve the cases".

5. Rock identification at Key Stage 3 (11-14) - 1 hour

How rocks may be identified by "beginners", and how the specimens may reveal evidence about their origins.

6. Earth Science out of doors at Key Stage 3 or 4 - I (11 to 16) - 1 $^1/_2$ hour

How to apply the principles of Earth science in the immediate surroundings of a school, even without a rock in sight! A brief "walkabout" around the school grounds, applying the principle that "the present is the key to the past".

7. Earth Science out of doors at Key Stage 3 or 4 - II (11 to 16) - $^1/_2$ hour +1 hour on site + travel

How to use a local churchyard, town centre, or nearest exposure of rocks in teaching Earth science. Starts with a colour slide survey of the possibilities for investigations out of doors. If practicable, this is followed by a visit to the nearest site of interest to the school, to put ideas into practice.

8. The school collection - open ended timing

How can a school's geological collection be used? This will clearly depend upon the state of the collection, if any! Advice can be given about where to obtain further materials cheaply etc.

9. Problems solved/ questions answered - open ended timing

Teachers may wish to allocate time for formal discussion, where colleagues bring their own problems and ideas, which have arisen during their teaching of Earth Science.

Resources display and sales point - ongoing during session

The team carry with them a small display of publications from commercial publishers, as well as stocks of booklets written specifically for the National Curriculum by the Earth Science Teachers' Association: also maps of the ocean floors, world geology, volcanic regions etc.

Progress

The Earth Science Education Unit officially started in September 1999, just before the start of the school year in UK. It has therefore seen little action at the time of writing. However, a number of pilot meetings have been run, and the programme has been well received. School staff feel that the programme is relevant to their needs and are incredulous that it is available at such low cost! A major aim of the Unit is to enthuse teachers, hoping that such enthusiasm will be reflected in the teaching of their students. It is also hoped that teachers who know little Earth science will have their confidence boosted as they learn more about the subject themselves and become more aware of the possibilities available, both human and physical, in their local areas. Feedback from the pilot sessions so far indicates that these aims are being achieved.

The authors hope to be able to provide an update at the Conference and are looking forward to sharing experiences with others who may have delivered Earth science INSET in their own countries.

Learning and teaching in Higher Education in the UK: an Earth Sciences perspective

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Higher Education in the UK is changing rapidly in response to various drivers including the 1997 report of the National Committee of Inquiry into Higher Education (NCIHE: The Dearing Report). Quality assurance of good practice in learning and teaching is high on the agenda (though low on the priority list due to the over emphasis on research as a result of the funding mechanisms), Key Skills are also becoming a focal point for such good practice and the use of computer and information technology (C&IT) is becoming increasingly important. Furthermore, these demands are being placed on academics in an environment of increasing student numbers (with the introduction of the concept of mass higher education) and, often, reduced resources (despite requiring students to pay £1000 per year as from October 1998).

This abstract briefly outlines the two of the major initiatives currently being established in HE - Subject Benchmarking and the Learning and Teaching Support Network.

Background - the academic climate in the UK.

Teaching Quality Assessment (TQA) and the Research Assessment Exercise (RAE): funding is the major driver behind any process in Higher Education and the level of funding available to Universities for research is dependent on good results in the RAE. The assessment is broadly based on the quality and quantity of research papers published in recognised international journals. The outcomes of the TQA result in gradings for departments - higher gradings are likely to attract more students and, hence, there is an incentive to produce high quality paperwork and learning and teaching practice when your department is up for review.

The practical upshot of these two processes is that learning and teaching development is low on the agenda for most of the time whilst academics are pressurised into publishing but becomes high priority in the months leading up to TQA. Not an ideally balanced system to provide an optimum learning environment for the students or working environment for the staff.

Benchmarking: The Quality Assurance Agency for Higher Education (QAA) was established in 1997. It has responsibility for assessing the quality of higher education (HE) in England and Northern Ireland from 1 October 1997 under the terms of a contract with the Higher Education Funding Council for England (HEFCE).

The QAA is piloting a 'Benchmarking' scheme to assure standards. The report of the NCIHE proposed that benchmark information should be used by institutions, as part of their programme approval process, to set degree standards. Draft statements have been produced by Chemistry, History and Law and, at the time of publication of these proceedings, the Earth and Environmental Studies Benchmarking Panel is about to begin work chaired by Prof. Dave Eastwood of the University of Ulster. Much of the work will have been completed by January 2000 and further details will be given in the presentation.

Learning and Teaching Support Network: in response to the Dearing Report the Higher Education funding councils of England, Northern Ireland, Scotland and Wales have set up the Teaching Quality Enhancement Fund. The purpose of this fund is to reward high quality and encourage improvement through funding directed at three levels: the institution, the subject or discipline, and the individual academic.

The subject strand of the fund is given over to the learning and teaching support network (LTSN) for higher education, which aims to promote high quality learning and teaching by providing subject-based support for sharing innovation and good practices. The network will consist of 24 subject centres and a Generic Learning and Teaching Centre.

At the time of writing a bid has been submitted to the funding councils for a Geography, Earth and Environmental Sciences subject centre by the Royal Geographical Society with the Institute of British Geographers (RGS-IBG), the Geological Society of London, the Committee for Heads of Geography Departments in HE, the Committee for Heads of Environmental Sciences in HE (CHES) and the Committee for Heads of University Geoscience Departments (CHUGD). Further details of the structure and programme of work of the subject centre will be available by January 2000.

The Institute for Learning and Teaching in Higher Education (ILT): after much consultation across the HE sector the ILT was launched in June 1999. The ILT is a membership organisation open to all those engaged in learning and teaching support in higher education. The ILT will provide publications on learning and teaching topics, a Website, networking opportunities and research databases. In addition, the ILT will be closely linked to the Subject Networks. Membership will be dependent on the production of a portfolio of evidence of teaching knowledge and skills. Again, further information will be available in January 2000.

Improving the teaching of plate tectonics: teacher education by means of a scientific approach that deals with teacher misconceptions

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Background

Although plate tectonics is taught to all children in schools in England and Wales, there are a number of issues that make this teaching less effective than it might be.

These issues are being addressed as part of an INSET programme (In-Service Education and Training) being offered to schools by the Earth Science Education Unit at Keele University. The Unit is able to offer Earth science INSET to secondary (11-16) school science departments at minimal cost, thanks to a grant from the UK oil industry (*UKOOA). The INSET programme is offered as a series of interactive workshops and, in its first year, the programme is being piloted in three UK regions.

Plate tectonics and the structure of the Earth were chosen as the topics of one of the workshops for the following reasons:

- these topics are in the National Curriculum for Science at Key Stage 4 (14 - 16 year olds) and so are part of all science examinations syllabuses for 16 year olds;
- since plate tectonics is also part of the National Curriculum for Geography at Key Stage 3 (11-14 year olds), science teachers find it difficult to develop, at Key Stage 4 level, the understanding that pupils bring from Geography;
- the Earth science background of the majority of teachers that teach plate tectonics is very poor;
- as a result, they hold a variety of misconceptions about plate tectonics and the structure of the Earth;
- in some areas they exhibit a major lack of knowledge and understanding;
- errors and oversimplifications on these topics in science syllabuses, examinations and textbooks exacerbate these problems.

The task of the Earth Science Education Unit team has therefore been to develop a workshop approach that:

- engages and motivate teachers;
- builds background knowledge and understanding and deals with misconceptions in a non-threatening way and
- shows how plate tectonics can be presented effectively in a laboratory/classroom context.

The Geography/Science Issue

14 - 16 year old pupils studying science will previously have been taught the following in Geography (taken from the programme of study):

- the global distribution of earthquakes and volcanoes and their relationship with the boundaries of the crustal (sic.) plates.

The challenge for science teachers is to take this basic knowledge and develop it into an understanding of plate tectonics and the structure of the Earth in a scientific context, without simply repeating what pupils should have previously learned.

The poor backgrounds of Earth science teachers

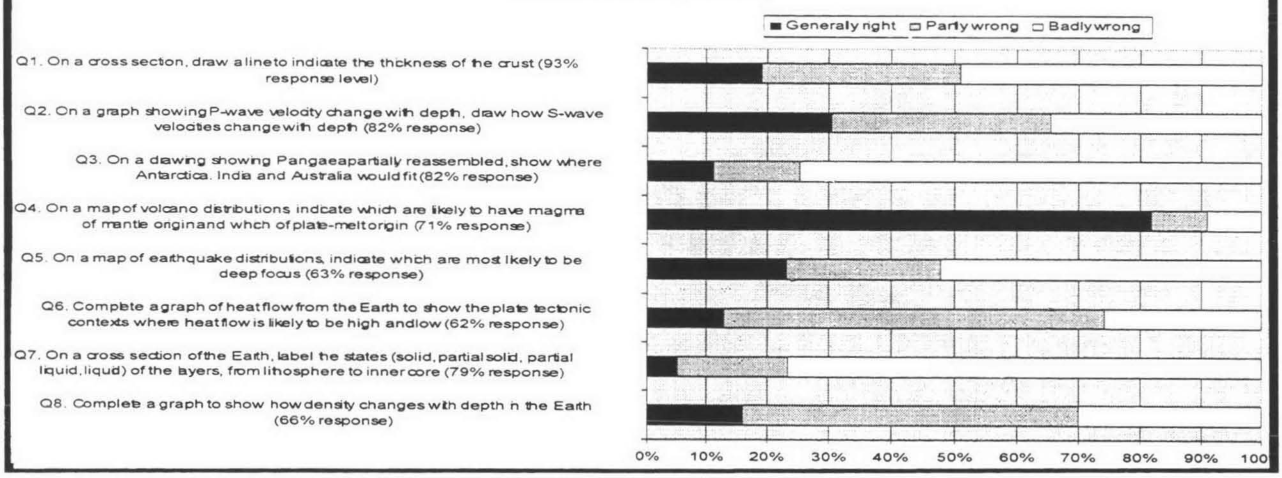
Research presented at GeoSciEd II in Hawaii (King, 1998) showed that the background knowledge of teachers teaching National Curriculum Earth science in UK schools is very poor and indicated a great lack of background understanding of Earth science topics.

Evidence from research on teacher misconceptions

To ascertain the level of knowledge and of misconception amongst teachers currently involved in teaching National Science Curriculum Earth science, participants at recent workshops on plate tectonics were given a range of questions at the start. Their responses are shown in Figure 1.

These show a range of issues, of differing levels of significance. Of particular reference to the processes of plate tectonics, it is significant that the vast majority were not aware of the states of different layers of the Earth; more than a third thought the asthenosphere was solid and most thought the mantle below the asthenosphere was partly molten; some thought it was liquid.

Figure 1. Responses of teachers before INSET to questions on plate tectonics and the structure of the Earth (76 respondents)



In addition, nearly half the teachers thought the crust (mean thickness about 18 km.) was much thicker than it really is; they indicated mean thicknesses of 50 km or more with some thinking the crust is more than 200 km thick.

In questions relating to the evidence for plate tectonics, most were unable to indicate which earthquakes shown on a map of South America were likely to be deep focus. Most did not realise that a subducting plate would cause a reduction in heat flow from the Earth and that this can be used as evidence for subduction.

Although most were unable to reassemble Pangaea correctly, the majority did realise that volcanoes in oceanic areas had magma sources in the mantle whereas the main magma source of continental volcanoes was the melting of plate material.

Overall, these responses showed a high level of lack of knowledge and of misunderstanding of the processes of plate tectonics and the evidence for them. These issues must be addressed if teachers are to gain a proper understanding of this topic before teaching it to pupils.

Syllabus and textbook oversimplifications and errors

A recent survey of examination syllabuses in science for 16 year olds showed that, in the area of Earth science, the mean number of errors and oversimplifications in the eleven syllabuses available to schools was 2.6 and ranged between 6 and 1 per syllabus (King et al, 1999). Syllabus errors relating directly to plate tectonic processes included references to plates of Earth's crust (rather than lithosphere), Q waves (for S waves), the Earth's semi-solid mantle, etc. In analysis of examination papers during the same survey, an average of 10% of the Earth science questions contained inaccuracies (ranging between 60% of the questions on one paper to none in some of the others). Plate tectonics-related errors again referred to the semi-solid mantle.

Textbooks too continue to give problems. The situation has not remained as bad as noted by Arthur (1996) but some recently-published textbooks still contain plate tectonics-related errors, for example the Key Stage 4 textbook published in 1997 that shows the mantle being made of 'hot sticky molten rock called magma'.

The 'Interactive Plate Tectonics' workshop

The 'Interactive Plate Tectonics' workshop was designed with these issues in mind. It also took into account experience which showed that no level of knowledge of plate tectonics or the structure of the Earth can be assumed in teachers attending INSET. Indeed, when the workshop was first run assuming some basic knowledge, it was not well received.

The workshop falls into four main phases, as follows:

- **Phase 1. Plate tectonic knowledge from Geography**. A series of photographic slides illustrating plate tectonic processes is shown. These are taken from a Key Stage 3 level geography film strip. The slides are used to present plate tectonics as a series of facts and no explanations or evidence are discussed at this stage. This is shows the understanding that Key Stage 3 children might bring from geography to their Key Stage 4 science lessons. It also gives the teachers present at the INSET session a grounding in the basic ideas of plate tectonic ideas and the structure of the Earth.

Figure 2.
The plate tectonics evidence and explanation sheet

Plate tectonics
- what is the evidence, what are the explanations

Concept shown on slide	Description	Evidence	Explanation	Activity
The structure of the Earth	The Earth has a crust, mantle and core			SoE2 E2 SoE2 E3
Tectonic plates	The outer part of the Earth is divided into discrete piece called plates			
Oceanic plates	Plates are thin pieces of lithosphere (average 100 km thick)			
Plates carry continents	Some plates carry continents (lithosphere can then be 150 km thick or more)			
Etc.	Etc.			

- **Phase 2. Developing a scientific understanding** Then the challenge is presented, 'How do we take this basic knowledge and turn it into a scientific understanding of plate tectonic processes appropriate for Key Stage 4 children?'

  The answer is to revisit the slides in which the plate tectonic ideas were presented as 'facts' and ask scientific questions about these facts, namely, what is the evidence for them and second, how can they be explained in scientific terms. During this interactive question and answer sessions, the minds of the teachers are focussed on these questions using a sheet, part of which is shown at reduced scale in Figure 2.

  The following concepts, from the photographic slides, are covered:
  • the structure of the Earth; • tectonic plates; • oceanic plates; • plates carry continents; • mantle movement; • plate collision; • oceanic plate collisions;
  • oceanic vs. continental plate collisions; • continental plate collisions; • diverging plates; • transform faults; and • break up of Pangaea.

  The teachers are encouraged to note down the evidence and explanations as they are discussed. The discussions refer to a series of diagrams taken from textbooks that illustrate key points.

  When all the concepts have been covered, the teachers are presented with a completed sheet listing major points of evidence and explanation.

- **Phase 3. An interactive practical approach** A series of practical activities relating to plate tectonics and the structure of the Earth are then made available to participants. These are all taken from the Earth Science Teachers Association (ESTA) publication, 'Investigating the Science of the Earth 2: Geological changes - Earth's structure and plate tectonics' (Kennett and King, 1996). They are referred to in the 'Activities' section of the sheet shown in Figure 2.

  Participants try out the activities and then demonstrate the activity and feed back their findings to the rest of the INSET group. Teaching strategies and technical matters are discussed and the value of the activity in demonstrating key plate tectonic processes is debated.

- **Phase 4. The evolution of plate tectonic theory** In a brief concluding phase, the teachers are presented with a scrambled list of the main players and their dates in the story of the evolution of plate tectonic theory. Unscrambling this illustrates the development of the theory and the story over time.

The workshop seeks to develop the understanding of teachers beyond that necessary for Key Stage 4 teaching so that they have a broad picture of plate tectonics on which to base their future teaching.

Feedback

Feedback has been very positive, with such comments as, 'now have a greater depth of understanding to explain plate tectonics', 'have more confidence with improved knowledge', 'will include new ideas in our scheme of work', ' excellent', etc. This should inspire the Earth Science Education Unit team to greater heights!

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* UKOOA is the UK Offshore Operators Association.

Inclusion of All Students in Fully-Accessible, Technology-Supported, Field-Based Marine Science Camps: The Ocean of Potentiality Project

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Abstract

Reform-minded national standards call for "science for all" (American Association for the Advancement of Science, 1993; National Research Council, 1996; Rutherford & Ahlgren, 1989, Rev. 1990), yet many educators and counselors remain unaware of science curricula or instructional strategies that make science accessible to students with disabilities (Cawley, 1994; Forgione, 1999; Norman, Caseau & Stefanich, 1998). If earth systems science field excursions are truly to be for all students, then they must be fully accessible to all students, including those with disabilities who traditionally have had little opportunity to explore and learn in outdoor settings.

The Ocean of Potentiality project is a multi-faceted effort aimed at developing communities of learners, including scientists, educators, students and family members, to work together toward a fully accessible science and technology curriculum for students in Hawaii. One portion of the Ocean of Potentiality project aims to develop and test models for inclusion of all students in fully-accessible field-based and technology-supported marine science camps. Here we reflect on our experiences at one of these camps, the marine science camp held at Kalaupapa on the island of Molokai.

Toward a model for Marine Science Camps for All.

Each camp is a 2-to-5 day event held during the school year in rural settings in Hawaii. The camps are heterogeneous in that they include persons with and without disabilities and all are fully included in camp activities. Participants reflect Hawaii's diverse ethnic groups, cultures and rural/urban environments. Intergenerational activities connect adolescents with adults who range from graduate students to retired elderly.

The camps strive to focus less on imparting information and more on building relationships and creating intentionally invitational educational opportunities (Purkey, 1996). Planned camp activities provide the structure needed by students with mild to moderate cognitive or emotional impairment. And, an accessible science camp for all requires considerable contingency planning for flexibility to respond to the interests, strengths and abilities (as opposed to the needs and disabilities) of all participants. One key to flexibility is the use of many forms of cooperative small groupings.

The richness of the camp experience develops in the many informal and loosely structured opportunities for young people to interact with each other and with the adults who are there and ready to serve as models and mentors. Adults include scientists, educators (science teachers, special educators and counselors), family members, related service personnel (e.g., sign language interpreters) and others with special knowledge and experience related to camp themes. Camp themes vary, but serve to weave together camp activities related to science, mathematics, technology and careers, and in these settings the human drama of science emerges (i.e., real people and real stories of human challenge) when adults with
and without disabilities share their passion for their science-related work.

Each camp is somewhat different according to where and when it is held and who participates. Nevertheless, each has in common opportunities for participants to

1. engage in field-based, hands-on exploration of the interrelated marine and aquatic resources and ecology of a coastal area;
2. gain skills in using technological devices to support scientific observations, personal learning, communication, mobility, leisure and recreation, and other aspects of living;
3. explore how native and immigrant populations have interacted with the natural environment;
4. identify, investigate and analyze environmental issues;
5. formulate visions for alternative futures aimed at preservation and sustained use of natural and cultural resources;
6. work in heterogeneous cooperative learning teams that include family members, educators and scientists, as well as students, to experience how human differences and strengths promote synergy and creativity;
7. participate in recreational and leisure time activities of choice that enhance self confidence and promote social growth; and
8. give back to their communities through socially responsible volunteer projects.

The Ocean of Potentiality Science Camp at Kalaupapa.

Here we describe one of the camps to exemplify the notion of Ocean of Potentiality Science Camps: the Spring 1999 science camp held at Kalaupapa on the island of Molokai.

Kalaupapa, on the central north shore of the island Molokai, is an isolated, low and flat peninsula formed by a shield volcano that juts seaward out from spectacular 2,000-ft sea cliffs. Kalaupapa is considered a national treasure both in its rich natural ecology and its painful human history as a place where—until recently—people afflicted with Hansen's disease (known throughout the world as leprosy, a disease shrouded in fear and ignorance for centuries) were forcibly exiled for life. Today Kalaupapa is a National Historical Park, jointly administered by the State of Hawaii Department of Health and the National Park Service of the U.S. Department of Interior.

Kalaupapa is probably best known from the accounts of the ministry of Father Damien (Law & Wisniewski, 1988). Fewer than fifty now-elderly residents, all former Hansen's disease patients who have been cured with antibiotic therapy, still remain there, this time by choice to live in the place where they spent most of their lives. Kalaupapa's human drama is compelling and reveals how a dreaded, highly visible disease led to inhumane treatment of its victims. Kalaupapa is surely a place to study the roles of medicine and epidemiology. But it is just as surely a place to learn about human ecology, including the personal (Breitha, 1988) and political dimensions of disease (Scheder, 1992).

Holding this Ocean of Potentiality Science Camp at Kalaupapa brought human ecology as well as science and technology together in several ways. Two groups met and interacted: adolescent students, including special education students identified by laws (Education for All Handicapped Children's Act, 1975; Americans with Disabilities Act, 1990; Individuals with Disability Act (IDEA) of 1990, Rev. 1997) that set them apart from their peers in public schools, and some of the residents of Kalaupapa, former patients whom society ostracized because of their affliction with Hansen's disease.

Historically, the residents themselves had been removed from contact with their family and children, so they lived sheltered lives apart from mainstream society. Today, tourists may arrange day-trip tours with the residents, but only their invited guests or adult volunteer work groups, often church-related, are permitted to stay overnight. Thus, our presence with adolescents, including students with mild to moderate cognitive and emotional impairments and with adults and adolescents with several physical disabilities—and our purposes as a science camp were unusual at Kalaupapa.

For each of the science camps practicing scientists, science-related career specialists, and individuals with special knowledge of the camp areas—with and without disabilities—help lead science and career awareness activities. At Kaluapapa, Superintendent Dean Alexander, a uniformed National Park Service ranger, took us to selected natural and historical sites on the peninsula, bringing to life the nature of his work to not only preserve rare native habitats for several endangered endemic Hawaiian plants and animals but also to preserve archeological resources, from early Hawaii contact (about 1,000 years ago) to preserving Kalaupapa Village so that they remain for the education and enjoyment of future generations.

Dr. Richard Radtke, the originator of the Ocean of Potentiality project, has been the research oceanographer at all of our camps. He is severely disabled from Multple Sclerosis (quadriplegia) yet travels worldwide to conduct his research. At the science camps, he travels with us to all our sites, participates in observations and discussions, and takes charge of assembling computer data recorded by student participants, including video and digital camera images.

Also a participant at several of our camps is Mr. Makia Malo, a nationally recognized Hawaiian storyteller and gifted communicator. Mr. Malo was sent to Kalaupapa as a young boy and is now blind and disfigured from the effects of Hansen's disease. At night, in dark settings at the camps he riveted us with dramatic, and sometimes scary stories of life at Kalaupapa when he was a boy.

At Kalaupapa, the other residents who hosted us also shared stories with us as we ate together, traveled from site to site together, and shared fellowship. Their obvious enjoyment of life and their keen observations about the natural wonders of Kalaupapa greatly enriched our experience, giving testimony to the value of listening to and learning from folk knowledge as well as science.

As place for study of the natural environment, Kalaupapa is both spectacularly beautiful and relatively untouched by modern development. As much as possible, we used existing, proven curriculum resources, modifying approaches to elicit and build on experience of the participants, support field-site inquiry, and to make activities accessible for all. Activities included observations of the shield volcano, and how geology determined such habitats as dryland and wetland forests and the differences in leeward and windward coastal areas. Several activities engaged students in qualitative and quantitative observations of the deleterious effects to native habitats of the rampant spread of nonnative, introduced ornamental foliage, feral pigs and axis deer. Sightings of humpback whales and a rare monk seal spurred discussions about endangered marine mammals and sustainable environments.

Opportunities for social and affective growth were supported in semi-structured leisure activity options, including active snorkeling and organized beach events as well as quiet opportunities to read, use computers, and to work on personal "camp memory books". We taught students how to use video and digital cameras, which they used in a variety of ways: interviewing each other about experiences, focusing on aesthetic framing of experiences, video documenting events, video images for their memory books, and subsequently to add to the Ocean of Potentiality web pages.

Dr. Radtke especially stressed the importance of always including activities to "give back" to the community. At Kalaupapa we conducted a marine debris beach cleaning project and a community dog wash. Why a dog wash? No children are permitted to live on Kalaupapa, so our suggestion of a car wash seemed odd to the residents unfamiliar with this teenage activity. Most of the residents keep dogs as companions, and they welcomed our offer to shampoo their dogs.

All participants in the Kalaupapa marine science camp — very much including all the students and all persons with disabilities — were learners as well as teachers. We've said little here about the many ways that the students themselves contributed knowledge, skills, understanding, and caring so that together everyone successfully participated in the science camp.

The Oceans of Potentiality project is planning future science camps, retreats and other community activities in support of science for all students in Hawaii.

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Improving Undergraduate Geoscience Instruction Through Action Based Research Teams

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Improving undergraduate science courses is a continuing and on-going concern of university and college faculty. Reports such as the National Science Foundation's *Shaping the Future* (1996) and the Boyer Commission Report, *Reinventing Undergraduate Education: A Blueprint for America's Universities* (Boyer Commission, 1998) underscore this concern. Both reports indicate undergraduate science courses tend to isolate students from the content and the professor. Much of this is attributed to a teacher-centered autocratic style of teaching, which is quite often the norm for the university science classroom. These reports recommend that learning should be integrative, wherein the professors incorporate laboratory work, group work, and discussion sections into their lesson plans. Faculty in the Department of Earth and Atmospheric Sciences at Purdue University have developed action based research teams to develop student-centered classrooms.

The goal of a student-centered classroom, where students take an active role in their learning process and the professor becomes a guide or mentor, is reflected in many of the innovations suggested for undergraduate science instruction. For example, *Powerful Ideas in Physical Science* (American Association of Physics Teachers, 1996) has students actively constructing their understanding of physical science concepts through investigation and small group discussions while the professor facilitates student work through carefully worded dialogue with the investigative groups or whole class discussions. Other examples of student-centered teaching are found in the articles published in journals such as *The Journal of College Science Teaching* (Adams & Slater, 1998). These teaching tips and ideas appear to have worked well for the individuals that have tried them. Yet, if these techniques and materials are effective why are there not more institutions and individuals implementing these elements into their instruction?

Faculty members at Purdue University in the Department of Earth and Atmospheric Sciences decided to address this issue head-on. The faculty collaborated on a National Science Foundation funded project (Purdue University, 1996) which utilized a partnership of scientists, science educators, master teachers, graduate students, and undergraduates who focused on promoting improvements in the teaching geosciences. The goal of the collaboration was to enhance the education of preservice teachers and the education of science, mathematics, engineering and technology majors in their introductory courses. The method of changing the curriculum was through the use of action based teams.

Action based research provides a method to manage change in an instructional setting, produce documentation as to the effectiveness of changes, and provide information on further changes (Keating, Diaz-Greenberg, Baldwin, and Thousand, 1998). Action based research is defined as: "an ongoing, self reflective process that involves critical examination of teaching practices or theories to improve personal practice and the education of the students" (Hamilton, 1995, p. 79). Thus, "the action research framework is most appropriate for participants who recognize the existence of shortcomings in their educational activities and who would like to adopt some initial stance in regard to the problem, formulate a plan, carry out an intervention, evaluate the outcomes and develop further strategies in an iterative fashion" (Hopkins as cited by MacIsaac, 1995). "In this way 'the process of teaching and the role of research in science teaching have a common end - to enhance science instruction, students' learning, and the assessment of both" (Kyle, Linn, Bitner, Mitchener, & Perry, 1991).

Efforts of implementing action research models in higher education settings, though limited in number, support our belief that action research is an effective means for the reform of teaching introductory college and university science (Chism, Sanders, & Zitlow, 1987; Cross, 1990; Fedock, Zambo, & Corbern, 1996; Nakhleh, 1994; Schratz, 1990). Additionally, results from the action based research project at Purdue University indicate that involving action based research teams in the study of both content and pedagogy increases the amount of connected knowledge and student-centered pedagogical knowledge gained by students, undergraduates, graduate students, and university faculty.

In conclusion, an important element of the action research based model is communicating the outcomes of your efforts to others. This can be done through a variety of forums. At Purdue University the faculty teams have reported their results during faculty colloquia. One outcome of this is that peers will know what your have done, why you have done it, and what impact is has had on students. You have shown, with data, that a particular innovation works within the context of your institution. A secondary outcome we have observed at Purdue University is that evidence collected through action research speaks to science faculty. One of the teams in this project has reported that other faculty members have seen the changes that are occurring and are now in the process of bringing these innovations into their classrooms...classrooms that have not changed methods in 20 plus years. Not only does this have the potential to substantially improve undergraduate education in the sciences, but it also carries recognition by peers of efforts to improve teaching prowess.

Another aspect of using action based research as an ongoing practice for college science instruction deals with the issue of accountability. The data collected as part of a project, not only helps to evaluate and improve instruction, but also documents, the "value added" or achievement of course and program goals. The political climate, which translates into issues related to accreditation, make it clear that the products of action based research can provide the type of evidence that is being sought by entities external to the institution.

The literature on college science teaching is replete with examples of teaching innovations. Each of these innovations is, to a greater or lesser extent, unique to the setting in which they originate. Action based research provided a mechanism for faculty to implement change, systematically analyze the impact of the innovation, and finally adapt to the needs of their institutions.

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Global Science Literacy in the Japanese Contexts - Focusing on Earth Systems Education –

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There is no wonder that western countries are conducting challenges on the innovation of education which is so called, the 'Systemic Change of Education'. In the US we can point out two big guidelines for science education; *the Bench_arks of AAAS* and the *National Science Education Standards* of NRC. Analysis of those innovation shows that three major characteristics could be pointed out, namely; Constructivism, nature of science and technology, and systemic changes.

We are constructing a response to both of those factors which will provide guidelines for curricula that would be international in scope, and yet provide a cultural frame for science education programs unique to each society. We would trust that such guidelines, if followed, could provide for a more accurate rendition of the nature of science, one that would be relevant to children and adults of all countries, and that would facilitate communication and action concerning the social and environmental challenges faced by all countries in a rapidly developing global economy in which we are calling, Global Science Literacy.

We conducted a teacher training program on October 24, 1998 at the Shizuoka University and visited four different high schools in Shizuoka Prefecture, Japan where at least one science teacher had been attended the in-service training. One of the major goal of the in-service training is to introduce what we mean the "Global Science Literacy" in the secondary school curriculum. Interesting results were found and discussions based on these data were explained. By summarizing these results we develop suggestions toward the innovation of science education in the Japanese context which does work.

AGSO's Teacher Resources Kits and Training Sessions

Gary B. Lewis

Australian Geological Survey Organisation

The Australian Geological Survey Organisation (AGSO) is Australia's federal government geoscience research agency. The AGSO Geoscience Education Unit has operated since 1994 with the aim of increasing the awareness of school students, through their teachers, of the important role geoscience has to play in the environmental and economic future of the country.
One project operated by the unit involves the development of teacher resource kits for primary and secondary schools. These kits are developed to inspire non-geoscience teachers to introduce aspects of geoscience into their classrooms by providing simple to read background information and reproducible classroom activities.

The kits are developed by staff with recent teaching experience, but not necessarily with geoscience backgrounds, which ensures the appropriateness of the materials, especially at primary school level.

To date AGSO has produced over 30 different kits. These kits cover topics such as Plate tectonics, Earthquakes, Volcanoes, Geological Maps, Remote Sensing, Landslides and more.

The kits are advertised and sold at almost cost price around Australia with over 18,000 having been distributed over the last four years.

A recent evaluation shows that teachers estimate that they will use these kits with over 1 million times with students over the next two years.

While the development of the kits has been important, the Unit also operates a series of teacher training workshops based on the resources. These workshops aim to increase the worth of the teaching materials by empowering the teachers to use them in the classroom.

Sessions have been operated in Sydney, Melbourne, Perth, Brisbane, Hobart, Darwin, Newcastle, Wollongong, Wagga Wagga, Armidale, Cairns, Townsville, Geelong, Bendigo, Ballarat, Alice Springs and Tennant Creek and other major centres. These sessions have attracted 1800 teachers.

These projects, as well as the other AGSO Geoscience Education projects (such as field trips for government officers) are operated on a cost recovery basis. This means that the projects are at times heavily supported by other organisations such as the Australian Surveying and Land Information Group (AUSLIG), Minerals Council of Australia and commercial organisations.

Changes in GIS and their consequences to Geoscience teaching

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Introduction

GIS is changing and consequently Geoscience education should change. Why?

A Geographical Information System, or simply GIS, is a computer system for managing spatial data (Bonham-Carter, 1994). Considering the essentially spatial nature of the activities in Geoscience, it is not surprising that almost all of these activities require the building of a GIS for its accomplishment. Until recent times GIS was considered as an independent field of work, and people using GIS were considered specialists. The GIS programs have become at the same time powerful and user-friendly, whereas GIS hardware and software are now affordable even for students. This combination of need and opportunity can explain the GIS boom of this decade, and the generalization of their application in Geoscience in a few years. Geoscience teaching can benefit from GIS, and geoscience educators should adapt curricula to this new reality.

The evolution of GIS

Geoscientists integrate data from several maps of a region, and join map and tabular information, since the beginning of the Earth Sciences, centuries before the first computer was built. Map overlay with transparent copies was used, very tiresomely, without computers until the sixties, and even after this, because of the difficulty of access to expensive computers and programs. Even in 1984-5 the author coordinated a project to find areas suitable for sand mining in the São Paulo Metropolitan Area, combining eight overlays of 53 quadrangles at scale of 1:25.000.

The first generation of GIS programs begun in 1963, when H. T. Fisher developed SYMAP, a crude but efficient program for spatial statistics, with line printer output. Later, with his team at the Harvard Design's Laboratory for Computer Graphics he developed GRID and IMGRID, which made possible to do map overlay by computer (Burrough, 1998). GIS analysis done by these raster programs had their results presented in rough line printer listings. At almost the same time the first CAD (Computer Aided Design) and automatic mapping programs were developed. All these programs were expensive and run in very expensive mainframe computers, frequently with very limited access. The author had to work late nights or early mornings to use SYMAP in the beginning of the eighties, to benefit from a shorter turnaround time. The first image processing programs, used for remote sensing data, were still more expensive and hard to use than the GIS ones.

The second generation of GIS programs (from the late eighties) already had the main capabilities for an efficient work, but almost all programs inherited problems from their forebears. Those descending from raster overlay programs, like MAP and the first versions of IDRISI, were almost strictly raster-oriented, and it was impossible to make good map outputs from them. This was compensated by their good analytical performance. This performance was the problem of the other type, vector systems descending from CAD and mapping programs, like Intergraph and Arc/Info. Their beautiful graphic outputs sometimes had not too much to show, considering their limited analytical capabilities. These vector packages were expensive, and only run in mainframes, minicomputers or UNIX workstations, and needed expensive plotters and digitizing tables to work properly. Their raster relatives were more affordable, but you needed always to combine them with drawing programs to have presentable results. Remote sensing programs became more affordable, and some remote sensing treatment capabilities were offered by integrated packages like IDRISI and ILWIS. More powerful microcomputers and affordable inkjet printers and plotters allowed high quality output for almost everyone.

The third generation, from the early nineties, begun the raster-vector fusion which characterize modern GIS programs: even working better in raster or vector, they can work with data in the other data structure, directly of using add-ons, like the combination Arc/Info - ERDAS. Integrated programs, like IDRISI, could cope with almost all GIS tasks (excepting very large maps or databases). Prices became lower, and even large programs could be used in the new powerful microcomputers. Desktop mapping programs, sometimes more popular versions of larger GIS programs (like ArcView) had a leaner capability for a lower price.

Now in 1999 the GIS community sees new programs at still lower prices, a desktop mapping program by Microsoft destined to the general public, and even good programs for free, like GRASS and the Brazilian SPRING, free Internet data and courses, and at the same time the old workhorses become more powerful, also integrating Internet capabilities.

In thirty years hardware evolved from mainframes with memory of a few kilobytes to microcomputers with gibabytes, their prices falling from millions to a few thousand dollars; program prices from tens of thousands to around a hundred, if not for free. The general trend is, at the same time, the widespread use of GIS and a division of their users in two groups: a very small one, the real GIS specialists, who write programs or do basic research on GIS methods and applications; the larger group, of professions which will incorporate the GIS techniques in their work, soon even not using GIS in the title of their papers or reports. This is a situation similar to that affecting Geomathematics. In the sixties and seventies mathematical and statistical techniques were applied to geological problems, benefiting from the spreading of the first relatively affordable computers. All papers using some of this fancy numbercrunching declared its use: "Application of factor analysis to ...."; "Trend surface analysis applied to ...". Now these and other geomathematical techniques are routinely applied in Geoscience work, and the titles and the interests of almost all users are in the applications. Only a few eggheads read or publish in "Mathematical Geology". The trend in GIS is the same, and we will soon have two groups: the "Journal of Geographic Information Science" bunch and the general others. These will notwithstanding need to know how to use GIS in their Geoscience work.

Consequences for Geoscience

For the Geoscience professional or student the evolution of GIS means affordable programs and data combined with easy access to huge processing power. All the possibilities that we needed or even fancied to process our data are now at our fingertips.

Are we and our students prepared for this power? Not all of us, and not so well prepared. The evolution was too fast, even for the GIS experts. There are everyday new programs and versions, new hardware, new ways of doing things, new things to be done. Budget and time prevent us from being always up to date, specially if we have to be at the same time scientists and teachers. However our responsibility remains to prepare the new Geoscience professionals to make better use of this technology, thus making better Geoscience. Even non-Geoscience professionals, which take Geoscience courses for use in their careers or for general education, can learn more and better Geoscience if they use GIS.

Minimum GIS needs for all Geoscience professionals

All Geoscience professionals, in industry, research or teaching, need to have GIS skills at least in the following fields:

1. data acquisition, validation and conversion;
2. georeferencing of spatial information
3. map making, screen visualization, paper map and illustration layout and printing;
4. database exploration;
5. map combination and analysis;
6. professional applications of analysis, prediction and decision support GIS methods.

Educational activities, in class or lab, should be adapted to make students benefit from the now accessible technology. This can be done in micro or macro scale.

Adaptations in micro scale

Course programs and class preparation should use GIS to make Geoscience issues more understandable and attractive to students, and also to allow students to do class work in a similar way to that used by Geoscience professionals, which employ GIS for a large number of activities. At the same time, GIS should be taught to Geoscience students integrated to applications.

An early example of this integration is reported in Macedo (1997), on the use of GIS for non-GIS Geoscience students. Another more elaborate example of this kind of course material is presented in this Conference, by the author, in the paper: "Digital teaching material for geological applications of GIS". This is a result of a project funded by the Integrated System of Support to Teaching (SIAE), of the University of São Paulo, Brazil. The material, presented in CD-ROM, is designed to be used in formal and informal courses, for the teaching of GIS functions and abilities as well as of Geoscience issues. It consists in graded exercises, based in real data, to be used in basic courses (topographic and geologic map reading and making) and for applications: Environmental Impact Studies, Land Use Planning, Environmental Management and Conservation, Mineral Exploration, Regional Metallogenic Analysis, at the same time exercising GIS functions: organization, visualization, spatial query, combination, analysis, prediction, decision support and cartographic production.

Other Brazilian materials of this kind are available in the Internet, by Arlete Meneguette (http://www.prudente.unesp.br/dcartog/arlete/hp_arlete/ courseware), a general hypertext GIS course, and the application text "GIS in Environmental Projects", by Gilberto Câmara (http://www.dpi.inpe.br/cursos/gis_ambiente). A word search in the Internet will show numbers of such texts in many languages.

Adaptations in macro scale

More general changes are needed in Geoscience courses, to cope with these changes in technology. Some traditional Geoscience courses should be changed, merged or abolished from the curricula, and more emphasis given to GIS application skills. A change is underway at the Universidade de São Paulo, with the building of a Earth Sciences core curriculum, in which a "Introduction to Spatial Methods in Earth Sciences" fundamental course is being proposed for all Geology, Geophysics, Meteorology and Oceanography students, incorporating material now taught in Topography, Geodesy, General Cartography, Thematic Map Making, CAD and GIS courses.

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Practical Work in Earth-Science Education in Portugal in the Context of a National Programme

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What the Programme is

The Programme *Ciência Viva* was launched in 1996 in Portugal with the financial support of the Ministry of Science and Technology. It was designed to promote scientific and technological culture in Portuguese society, something that is crucial to the national science and technology policy. This Programme aims at creating a higher understanding of science education by promoting the teaching of science through practical activities and field based activities.

Several social groups, e.g. scientific and educational communities, science and technology professional and educators, were invited to join in the efforts being made to improve the scientific education of a large number of students. In other words, scientific societies, university departments, state research centres, science clubs, national parks, local councils and even private enterprises are involved. There is another dimension, related to the encouragement of regular contact between the students and the scientific work of science laboratories, which should be stressed. Through the direct participation of scientific and technological institutions, *Ciência Viva* has been providing support for the development of activities in schools for both teachers and students at an elementary and secondary level. In order to consolidate this involvement, a programme related to the twinning of schools and scientific institutions, constitutes a fundamental means of sharing resources and strengthening links between those who are involved in the construction of scientific knowledge and those more concerned and interested in science teaching and learning.

As mentioned above, twinning between schools and scientific institutions particularly Universities provided crucial sources for this Programme. The University of Aveiro is greatly involved in this task through an Action labeled "Scientific Education and Practical Work at School". This is an Action spread out from elementary to secondary schools.
In this paper, the authors present and discuss only the sub-actions carried out within this Action, with the support of Geology Department of Oporto

University, in the area of earth-science. These actions involve six secondary schools, fifteen teachers and approximately 200 pupils.

An important aspect, still related to the Pogramme under discussion, is the opportunity of supplying good quality of lab materials to elementary and secondary schools involved in. This issue is a relevant one, taking into account that it is no more possible to argue that the development of practical work cannot take place because there is lack of lab materials.

The context of earth-science in the Action Scientific Education and Practical Work at School

Practical work in earth-science has no tradition in Portugal despite the suggestions and recommendations referred to in the science curriculum. Otherwise practical work, which is carried out so far in the laboratory, is not close to the purposes put forward by educational researchers. Therefore, the main aim of this Programme has received an enthusiastic support from both science teachers, particularly earth-science, and educators. Let us try to understand what we mean by this.

When a practical activity, whatever it is, related to earth-science is designed, it is always developed in the context of time and space quite different from that of the natural phenomena. In fact a key difference between geologists and most other scientists is in their attitude toward time, a central concept in earth-sciences. Though many chemical reactions in the laboratory operates over time periods of seconds, geological processes take place over a much broader time range. This real difficulty is frequently held by teachers to justify the lack of planning practical activities. Here is one of the eventual reasons for the lack of practical work in earth-sciences´ classes. Programme *Ciência Viva* enables teachers to be faced with concrete and plausible experiences; they probably feel that it is possible to achieve new attitudes and make an attempt to overcome some of the natural difficulties concerned with practical activities in the laboratory.

Earth-science contents covered in the Action

First of all it should be emphasised that teaching and learning activities were designed in a problem-solving context; all of them are strongly related to a better understanding of the geological phenomena towards a systemic view of the geological events. Secondly, the set of tasks were designed for the 7th level , i.e. pupils aged 13/14.

The framework of the activities is both the concept of rock cycle, the circular process by which each group of rocks is formed from the others, and the several procedures which are responsible for this moving cycle.
Therefore, from this point of view, plutonic episodes, in Hutton´s terminology, could be the starting point. Laboratory activities related to crystallization and volcanic activities have been under discussion; study of everyday phenomena such as the release of lava and gas from the Earth´s interior to the Earth´s surface and into the atmosphere, or the new igneous rocks created when the magma cools and new minerals form by crystallization of the melt, were planned by the students. In depth discussions concerning with these events took place for solving problems elicited by students or teachers.

The igneous rocks formed during plate collisions are then uplifted as a high mountain chain. Uplift at plate boundaries, accompanied by crumpling and deformation of the crust, is part of the deformational and mountain-building process that geologists call orogeny. So, practical activities enabling the pupils to analyse the influence of horizontal and vertical forces on the origin of folds and faults were planned

After uplift, the rocks of the crust that overlay the uplifted igneous rocks are gradually weathered, eroded and stripped away. The same thing happens with igneous rock which is also weathered The rock debris and the dissolved substances produced by weathering are transported by streams to the ocean, there to be deposited as layers of sand, mud or other sediments. A set of laboratory experiences related to several types of transport, sediment deposition environments and also sedimentary structures have been carried out by the pupils.

The rock cycle is driven by plate tectonics. Rocks melt and igneous and metamorphic rocks form as plates subduct into the mantle. Practical activities related to a set of issues such as convection currents, consequences of these currents on the crust rigid units, i.e. plates, and sea-floor spreading were discussed, designed and implemented.
From all the above it seems clear that the common denominator of all of these activities is to support the construction of the idea of a dynamic Earth by the pupils.

Earth-science clubs

This is another dimension of the Programme out the classroom work. As far as earth-sciences is concerned, several field work activities were implemented particularly through the summer, under the label - Geology in the Summer.

The field trips have been organized strongly related to the perspective that pupils have to raise questions, to define methodologies for solving them, to make observations, to suggest interpretations, to participate in group discussions, to write short and concise reports and to make links with environmental issues. The field trips have been carried out with the support of teams in which geologists, educators and secondary school teachers were involved.

The geological areas selected display sedimentary and igneous lithologies and are located at the littoral areas at the centre north of the country

Final Comments

Several issues have been used to analyse the relevance of the Programme under discussion. Therefore a national meeting in which the different schools make the presentation of posters reporting their activities takes place, each year. So it is possible to share: experiences, strategies designed and implemented, difficulties felt by pupils and teachers, suggestions for the future and identified shortcomings.

The evaluation of the different activities was also carried out through written questionnaires administered to pupils and teachers. The main aim of these tools is to recognize the attitudes of the participants in the Programme *Ciência Viva*. The results obtained so far show that both the pupils and teachers recognize the relevance of practical activities for science learning and feel that there is a higher effectiveness in these practical science classes than in traditional ones.

Acknowledgements

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Multi-Agency And Academic Collaboration To Increase Public Knowldege Of Geologic Hazards: A Case Study From The Island Of Hawaii

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Volcanoes, earthquakes, tsunami, landslides, and flooding pose hazards to the people of Hawaii. Agencies, associations, and academic institutions are actively involved in educating the public about these hazards. They include the United States Geological Survey's Hawaiian Volcano Observatory, the National Park Services' Hawaii Volcanoes National Park, the National Science Foundation, the National Aeronautics and Space Administration, the National Park Foundation, the Hawaii Natural History Association, the University of Hawaii at Hilo, the University of North Dakota, and Hawaii public schools. This talk summarizes the senior author's experiences with these organizations to produce a citizenry that is knowledgeable about local hazards.

The United States Geological Survey's Hawaiian Volcano Observatory is the premiere agency for providing hazard information to the public and other state and government agencies. These efforts range from basic research and geologic mapping to producing an informative website (http://wwwhvo.wr.usgs.gov/), publications, and speaking at public meetings. HVO staff provide expertise and training to the rangers of the national park and accurate, timely information on earthquakes and eruptions. From an educators perspective, HVO provides a wealth of materials that can be used directly or with minor modifications to educate the public.

Rangers of Hawaii Volcanoes National Park stand, literally and figuratively, at the interface of the public and one of the world's most accessible dynamic geologic environments. The on-going eruption of Kilauea has offered exceptional opportunities for the public, teachers, and students to observe firsthand the dynamics of fluid basaltic lava flows. The park receives 2.5 million visitors per year and makes every effort to provide access to lava flows and coastal entries. Talks, guided walks, displays at park headquarters and the Jaggar Museum provide information on the structure, evolution, eruptive history and hazards associated with Kilauea and Mauna Loa. The park is also rare in the park service with the addition of a geologist to the permanent staff.

The public's lack of or limited knowledge about volcanoes has spurred several educational efforts. Most efforts target teachers and/or students with the long-term goal of an informed citizenry. Early efforts involved the collaboration between park staff and instructors at the University of Hawaii at Hilo to present content knowledge and hands-on experiences for local teachers. Two new courses, Geology of Hawaii Volcanoes National Park and Volcanology for Educators, were offered several times. The first course was entirely field-based and prepared teachers to guide hikes in the park. The second course offered a basic understanding of volcanoes, activities for the classroom, and field experiences.

Teachers expressed a need for curriculum materials concerning Hawaiian volcanoes. The park staff responded by teaming with the Hawaii Natural History Association to request funds from the National Park Foundation (http://www.nationalparks.org/), the official nonprofit partner of the National Park Service. One of the foundation's goals is to support programs primarily for education and outreach and visitor information. The foundation supplied funds to write A Teacher's Guide to the Geology of Hawaii Volcanoes National Park. The guide contains 18 lessons for K-12 teachers. Each lesson consists of Lesson at a Glance, Key Concepts, Lesson Outcomes, Teacher Background, Teaching Suggestions, and Useful References. The Teaching Suggestions contain 165 activities targeted for specific grade levels (K-3, 4-6, 7-8, and 9-12) and sixty annotated slides. The guide was provided, free-of-charge, to 200 public school in Hawaii. Training courses on how to use the guide were conducted on three islands and at a Hawaii Science Teachers Association meeting. The guide is still available from the natural history association and is available in an electronic version (http://volcano.und.edu/vwdocs/vwlessons/atg.html).

Mountain View Elementary School, on the lower southeast flank of Mauna Loa, expressed a need for geologic hazard education for upper elementary students. United States Geological Survey materials were used to develop lessons on defining hazard and risk, lava flows, air fall eruptions, earthquakes, tsunami, floods, and landslides. Information was conveyed by a series of demonstrations and activities, slides, videos, newspaper reports, and simplified geologic/hazard maps. Students recognized potential hazards and assessed risks to their community by reading accounts of past events and interpreting maps. They learned proper responses and basic mitigation measures to minimize the impacts of these hazards.

Capitalizing on the availability of geoscience educators, curriculum, and the accessibility of Kilauea volcano and lava flows, geologists at the University of Hawaii at Hilo requested and gained funds from the National Science Foundation to conduct Volcanology for Earth Science Teachers, a teacher enhancement project. Over the three years of the project, 75 middle- and secondary-school earth science teachers (25 each summer) from Hawaii, Alaska, California, Oregon, and Washington, spent three-weeks gaining information and teaching ideas about volcanic processes, features, and products. They become experts on volcano monitoring and geologic hazards and returned to their home states to conduct teacher-training courses. Although NSF funding has expired the course continues as Project LAVA (Learning About Volcanic Activity) and is available to all teachers (see http://planet-hawaii.com/hea/volcano/).

Collaboration between the Department of Space Studies at the University of North Dakota and staff at Hawaii Volcanoes National Park (and also Mount St. Helens National Volcanic Monument) led to a grant from the National Aeronautics and Space Administration's Public Use of Earth and Space Science data program. The grant supported creating and maintaining the VolcanoWorld website (http://volcano.und.edu). VolcanoWorld is dedicated to increasing public understanding about volcanoes. The site minimizes the use of scientific jargon and provides email access to volcanologists via the Ask-A-Volcanologist section. VolcanoWorld has grown to 20,000 pages and includes information on current eruptions, more than 500 volcanoes, volcanic parks, and teaching materials.

The diversity of the agencies, associations, and academic institutions involved have allowed geologic hazard information to be distributed in almost every conceivable form, from personal interaction between a park ranger and visitor, to teachers presenting accurate information to their students, to a curious member of the public asking a volcanologist a detailed question from thousands of kilometers away. Each of these exchanges is a step towards mitigation of hazards. In Hawaii, the hazards are immediate and obvious. In most other states, hazards are less frequent but can be equally as devastating. This work shows possible avenues of educational outreach and funding for projects. Similar long-term commitments are need in all coastal areas of the United States (and possibly the world) and in all large cities.

Climate Forecast Information for Distance Learning Activities in the Pacific

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Many Pacific islands depend on rain fed water systems in agriculture and other key industries. Thus, the potential utility of seasonal precipitation forecasts is clear: to more accurately predict fluctuations in water supply, or extreme event phenomena such as droughts or floods will reduce the risk of fatalities and monetary losses. The Schools of the Pacific Rainfall Climate Experiment (SPaRCE) is a cooperative field project involving local meteorological services, elementary, middle school, high school, college, and trade school students from various Pacific islands, atolls, and the U.S. One of the objectives of the SPaRCE program is to inform Pacific Island students as to the importance of their local climate and ways in which to analyze the daily rainfall values they collect.

In order to understand and prepare for shifts in precipitation patterns, the National Oceanic and Atmospheric Administration's Climate Prediction Center produces long lead rainfall anomaly forecasts for selected sites in the western tropical Pacific. The forecasts are generated using a statistical model that produces rainfall anomalies. These anomalies are reported as departures from the long-term seasonal means. These departures are adjusted to account for the precipitation variability at each location. The forecasts are for three-month periods and advance at one-month increments, so that there are twelve separate forecasts each month. For example, the latest forecast cycle is July-August-September 1999, August-September-October 1999, . . . , June-July-August, 2000.

Once the forecast is obtained via the Internet, EVAC scientists convert these anomaly forecasts into actual rainfall forecasts using monthly mean rainfall and standard deviations computed for each forecast site. Since the forecasts are not produced for every island in the Pacific, we have selected forecast sites that are relatively close to SPaRCE participants. For this study, we chose six sites which are located in the Solomon Islands, Vanuatu, Tonga, and Federated States of Micronesia (Figure 1). Using the data collected by the SPaRCE schools, we compare the recorded rainfall values against the forecasted values. In addition, climatological estimates are compared to the model-generated outlooks. The climatological values are determined by computing the mean rainfall for each month and using these values as the predictor for the forecast period. This allows us to observe how well the model performs and serves as an important scientific application of SPaRCE data. These comparisons are then passed on to the SPaRCE schools in the regions of the study. It is encouraged that the teachers use this climatological data and comparison analysis in their classroom lectures concerning local weather and climate. Moreover, showing to the students how the rainfall data that they collect everyday is used in an important scientific study hopefully increases their self-conscious efforts to record consistent and accurate data.

The preliminary results of the model validation reveal that the model performs slightly better than what climatology would predict. Figure 2 is a chart showing the maximum, minimum, and median actual errors shown for various lead times (error(1) refers to a one-month lead, error(2),a two-month lead, etc.) and for climatology (error(cl)). The vertical axis is the actual error (SPaRCE rainfall - Forecasted rainfall). The horizontal axis is the forecast associated with its respective lag time. This graph includes all six SPaRCE stations used in this study. Since the actual errors are shown, it is apparent that the model tends to over-forecast rainfall.

The model also shows definite spatial variability when comparing individual locations. For example, Figure 3 shows a time series plot using data from the Pohnpei Agriculture and Trade School (PATS) for validation. The vertical axis is rainfall amount in millimeters while the horizontal axis represents the three month forecast periods. This graph is particularly interesting because the forecast amounts closely follow the actual rainfall pattern. Both the one and two month lead forecasts capture the decrease in rainfall due to the 1997-1998 El Niño, but do not handle the magnitude of the decrease well.

The comparison of absolute errors between forecasts and climatology for PATS is shown in Figure 4. The vertical axis represents the absolute value of the error in millimeters while the horizontal axis is the same as in Figure 2. Immediately noticeable is that all forecasts have a lower error than climatology -- this suggests that these forecasts add additional useful information. The range in error is approximately constant throughout, however, fewer data points are available as the lead-time progresses.

The comparisons done by SPaRCE scientists provide distance learning to SPaRCE students in a couple of ways. First, they can see how their local rainfall measurements are significant to verifying climate forecasts and how important it is to be as accurate as possible when measuring local rainfall using the SPaRCE rain gauge. Secondly, they become more familiar with simple statistical techniques which is required for them to perform their own data analysis.

An important aspect of the SPaRCE project is to continue providing educational outreach to disadvantaged schools in the Pacific. Another objective of the program is to continue collecting data from SPaRCE schools. By performing comparisons and analysis of rainfall data that participants send in to SPaRCE headquarters, we hope to encourage students and teachers to do their own analysis/comparisons with the data they collect along with data collected by other SPaRCE schools.

SPaRCE also hopes to recruit additional participants from new sites that correspond to the model forecast sites. This project relies on continuous and accurate rainfall data from SPaRCE schools so that scientists can accurately determine how well the model performs. Updated forecasts for selected sites will be published in *The Pacific Tradewinds Quarterly*, the quarterly SPaRCE newsletter, with additional forecasts sent to schools that correspond with forecast sites (we plan to expand the analysis to several more sites in addition to the six mentioned above).

Acknowledgements

Special thanks go to Tony Barnston and Luke He with the Climate Prediction Center for producing the Pacific rainfall forecasts and for making them available so that this study would be possible. To learn more about the forecasts you can visit http://www.cpc.ncep.noaa.gov/pacdir/NFORdir/*HOME3.html.*

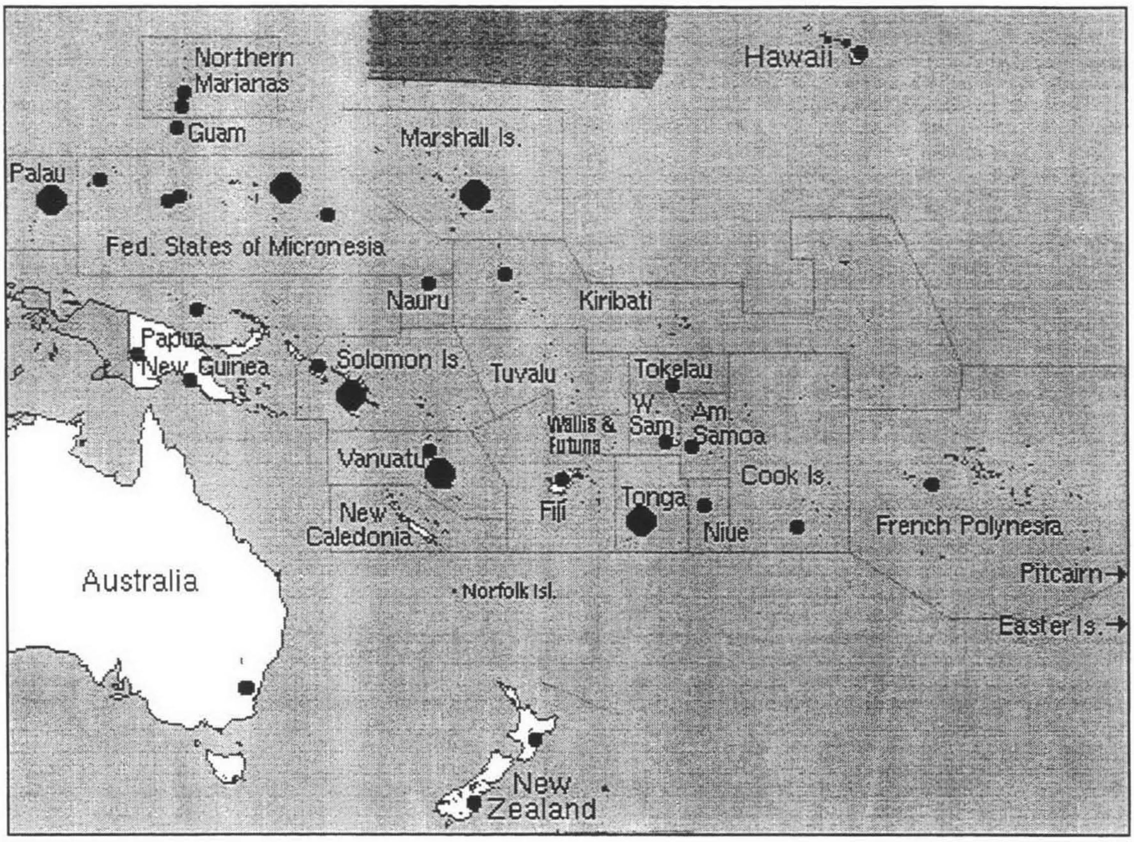

Figure 1. Location of participating schools.

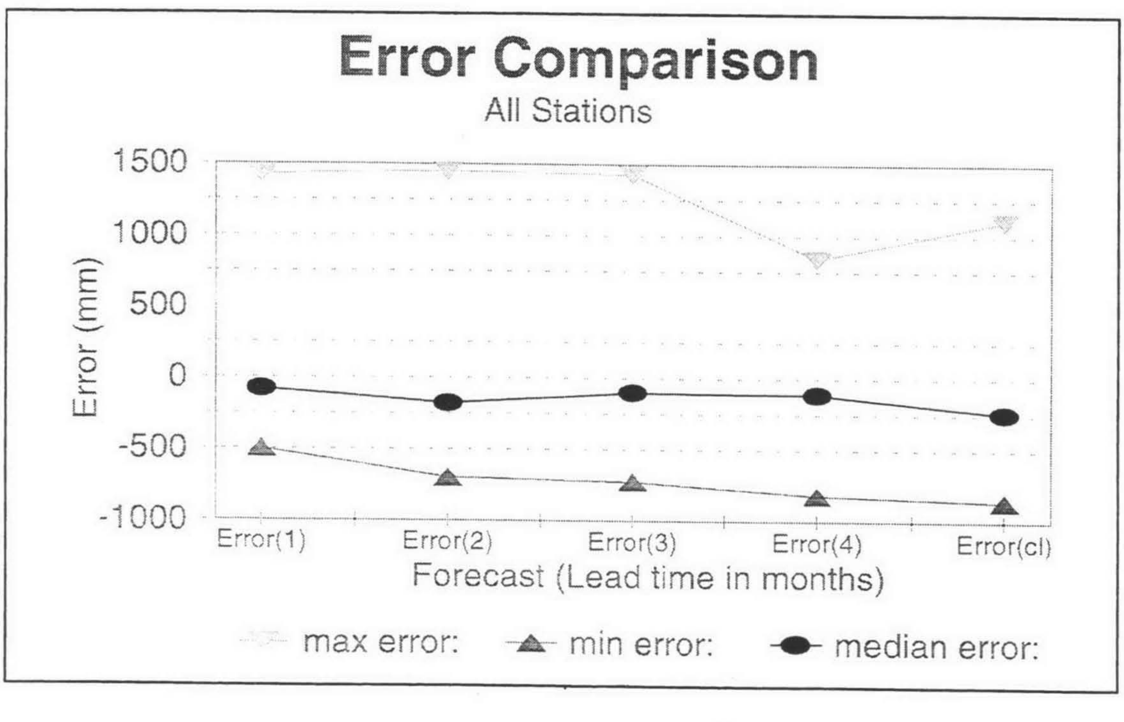

Figure 2.

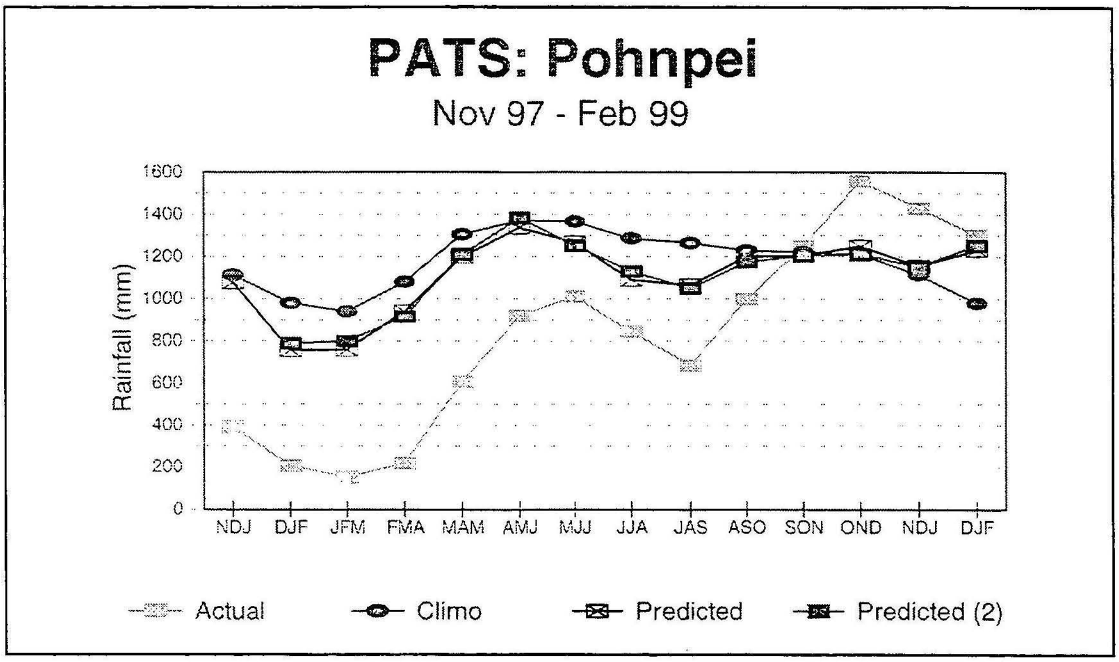

Figure 3.

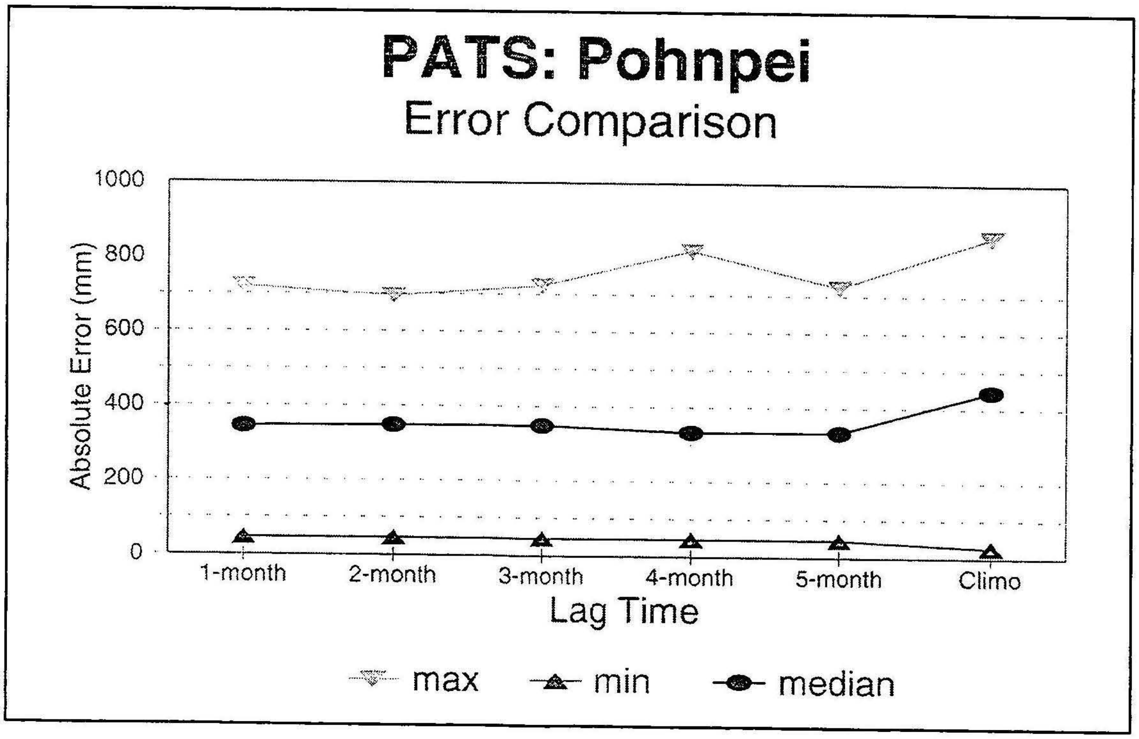

Figure 4.

The AGSO Earth Science Education Centre

Curriculum-linked hands-on activities raising the public awareness of the geosciences

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The Earth Science Education Centre (ESEC) is a new initiative of Australian Geological Survey Organisation (AGSO).

AGSO has long recognised the need within the community for geoscience education and has provided a wide range of educational programs and materials to schoolteachers and community groups.

The ESEC has been developed to meet several other community needs identified by AGSO. They are:

1. Access to hands-on curriculum-linked quality geoscience information for school students
2. Access to specialised geoscience workshops for college and other higher-level students

These needs will be met through the ESEC by providing:

1. structured and curriculum-linked geoscience activities
2. access to geoscience professionals with the education and communication skills and experience necessary to conduct the ESEC activities
3. specialised geoscience workshops for college groups within a laboratory-like environment using ESEC and other AGSO staff at AGSO
4. structured and curriculum-linked geoscience ESEC activities for use in other venues

The ESEC is a large purpose-dedicated space within the AGSO building, an adjunct to the large public foyer space that houses an impressive display of rocks, minerals, fossils and geoscientific information. The ESEC provides a safe, friendly, laboratory-like environment, with access to materials and equipment not normally available to school and community groups, within which structured hands-on geoscience activities can be undertaken. The ESEC will also provide an ideal space for conducting teacher training workshops and other AGSO education activities.

Initial ESEC offerings will be aimed at Yr5-6 senior primary school students. This cohort can be catered for with the equipment and materials that are presently available. Yr7-8 and Yr9-10 programs will follow as soon as possible with Yr11-12 college level activities to be developed in the final phase of school level program writing. Phased program development is anticipated to take 18-24 months.

Yr5-6 activities include content that satisfies the Science and Technology Key Learning Area strands of living things (changes over time), physical phenomena (sources and use of energy), products & services (mineral commodities) and Earth and surroundings (planetary science, earth structure, earth processes, geological time & resource exploration and exploitation).

Activities are designed to be completed during the site visit with each student completing perhaps 6-8 activities in all. Teachers are provided with pre-visit and post-visit activity and study suggestions together with guidance on the expected outcomes for each on-site activity. Students have a complete record of their achievements from the site visit and have the opportunity to follow up topics of interest through the post-visit activity suggestions. Teachers are encouraged to return to AGSO as their first point of contact for all geological questions.

Learning In The Field: Maximising Outcomes With Declining $ Income

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Introduction

Learning in the field has always been a part of geoscience education. Most geoscientists would agree that to properly observe, interpret and understand the Earth's features and their relationships one has to "get out in the field". Most geoscientists would also agree that field classes were the most effective and enjoyable learning opportunities in their own education. Geoscience employers consider such practical experience essential. Thus within the geoscience profession the need for learning in the field is not questioned. But can we do it more effectively and more efficiently, particularly in a politico-economic climate of declining resources for this type of education, and in an educational environment where computer-based "virtual" learning is becoming the fashion?

A rationale for field classes

Field classes are an effective learning strategy because they provide concrete experience in the real world. In terms of educational theory they encourage "experiential learning" (e.g. Kolb, 1984). In the field, the subject material and conditions can be experienced in their natural setting. The natural world is complex and commonly defies easy analysis or simple definition. Its complex, holistic nature encourages multidisciplinary problem solving and lateral thinking, the type of skills that will be required in later professional life. The unpredictability and novelty of the natural environment can also provide a sense of excitement or adventure which helps create and maintain enthusiasm and motivation. Field situations encourage utilisation of all the senses and this combination of information makes discovery more meaningful and memorable. Many field class activities require group interaction and co-operative problem solving. This strengthens communication skills and builds camaraderie and individual confidence. The field environment can promote peer learning and constructive social interaction among students and between students, staff and the general community. For all these reasons field classes can be the most valuable and effective component of geoscience courses. It is important to bring these learning advantages to the notice of education administrators who may not be aware of the substantial and unique benefits of learning in the field.

Importance of an integrated program

Field-based learning is more effective if individual field classes form part of an integrated program (e.g. Manning *et al.*, 1998). This program should also be planned in the context of the total course curricula. Too often field classes are run as simple add-ons to lecture and practical courses with little thought given to how they might complement these activities or reinforce theoretical concepts. The field program should also optimise the use of particular styles of learning not easily achieved in the classroom. In program design it is important to assess the critical factors influencing learning in the field and to develop an appropriate mix of classes. Ideally the field-based program should have a structured hierarchy of linked classes and activities designed to progressively develop student knowledge and skills over a course. The style of field class will vary with the specific learning objectives of each unit with which the field class is linked. Different styles can be introduced throughout an undergraduate program to reflect changing objectives related to changing learner maturity. Field class programs are also strengthened if there is lateral planning of activities across a particular year or level. This allows skills learnt in one unit to be applied, reinforced or built on in concurrent units. Integration in this way can result in synergistic benefits to the overall program. Demonstrated effective integration also provides a powerful argument for the value of field classes when their role is being questioned.

Getting organised

An effective and efficient field-based learning program requires good organisation. Field classes are more than outdoor activities. They have three common stages: planning and preparation; the field experience; and the post-field review. All stages are necessary to ensure a successful field class and to maximise the learning outcomes. Appropriate assessment and feedback are also key aspects of the learning process. Most geoscience educators and students can cite at least a few examples of less than satisfactory or even disastrous field trips. Major or contributing factors to such disasters are typically poor planning and lack of organisation.

Many factors need to be considered when planning and preparing for a field class. It is critical to establish the overall aims and objectives and to clearly communicate these to all participants. Students need to be prepared for field activities by briefings and appropriate reading research and/or class exercises. Other factors of paramount importance at the planning stage are the identification of an appropriate field class leader and teaching team, the selection of appropriate sites, organisation of logistics, health and safety issues and social-cultural considerations. Good planning is especially important when setting up a new field class in an unfamiliar area. Reconnaissance inspection is strongly recommended in such situations.

To be effective, combined field class activities should address all the recognised areas of learning including the cognitive, psychomotor, affective and interpersonal domains (e.g. Bloom, 1956; Ellington. 1993). Optimum use should be made of styles of learning which are particularly suited to the field environment. Appropriate styles include "hands on" learning, research-based learning, problem-based learning, co-operative or group learning, participant action research, community-based learning and contract learning.

Post-field activities allow participants to reflect on the experience and extend and reinforce their learning. Debriefing also helps participants disengage from the experience or link it to other components of the course. For example, there can be additional group discussion and individual presentations to the group, data can be processed, analysed and collated and a final report prepared. These activities, particularly if they result in a product, give a sense of successful completion. They also provide an effective route for integrating the field class learning into the broader course.

Combining activities

There are a number of strategies which can be used to make learning in the field more cost effective and some of these also enhance learning outcomes. Constructively combining activities is a common approach. Different levels of field classes can be combined into a joint class. For example, a second and third year geology class, involving separate or partially overlapping activities, could be held at a common site. Groups at the same level but from different institutions can also effectively combine. Sharing facilities can reduce costs through economies of scale as well as reducing staff and travel expenses. Students at different levels in the course or from different institutions can also contribute to each other's learning. Another approach is to combine field class activities with large field-based research projects such that staff can effectively combine their research and teaching responsibilities. This can have the added benefit of involving students in real problem solving within the project, which is generally much more stimulating than simply completing field exercises (e.g. McQueen *et al.*, 1990).

Linking with the community

Field classes can provide excellent opportunities for developing links between students, staff and the broader community. Field sites are commonly in rural areas where staff and students are required to liaise with farmers and the local community. These people are typically very interested in the student activities and the results of their studies. There are great benefits to both sides in keeping the local community informed and involved. Students can develop a sense of community responsibility and learn techniques of communicating and liaising with the general public, valuable skills for their professional careers. The community can gain new insights into the nature of their local environment and in some cases get useful scientific help with specific geological or environmental problems. For example, projects can be developed in partnership with the local community through Land Care groups to assist in land rehabilitation. In areas of active mining or mineral exploration, projects can be developed that assist industry or government authorities in their geological mapping and interpretation activities. For example, the University of Canberra, as well as other universities, have been involved for many years in providing information to assist mapping by the state geological surveys. These projects further allow students to be involved in real scientific work and discovery. They also bring them into contact with active professional geoscientists.

Alternate funding

Learning in the field is considered expensive, generally because of the costs of travel, accommodation and higher staff to student ratios. However in making comparisons with other forms of learning in classroom settings, rarely do the "bean counters" include the existing campus infrastructure costs. Nor is the relative effectiveness of the learning considered. A proper cost-benefit analysis may in fact reveal that learning in the field is cheap. Until University and Faculty administrators can be persuaded to undertake a proper analysis it appears that there will be ongoing pressure to reduce field classes in order to "save money". Maintaining or increasing field-based learning may well depend on developing alternate sources of funding. Some options are as follows:

Some geoscience departments in Australia are now linked to Special Research or Co-operative Research Centres. Where these have an education and training program it may be possible to get assistance for undergraduate field programs.

Sponsorship of student field studies can commonly be arranged through industry and government organisations or community groups. This may involve either cash contributions or logistic support.

Some senior student projects can be funded as part of collaborative contract research or consultancies where the appropriate funding is directed to help the students. This is common at honours and postgraduate level.

Combining field classes with field-based research activities by staff is another way of "piggy-backing" on a funded activity.

Some industry organisations and professional associations will sponsor field classes in their area of interest, particularly if students provide a product to demonstrate the learning outcomes.

Students can be asked to fund more of the cost. At many universities students already pay for their accommodation, food and some or all of the travel costs. The "user pays principle" may be invoked as justification, however science students already pay higher fees on the basis that these are needed to cover higher delivery costs due to expensive laboratory and field classes. Students can rightly protest a "user pays twice" principle.

Demonstrating the quality

It is important to monitor, evaluate and strive to improve field-based learning programs. If field classes are to be taken seriously by non-participants (and even participants) there have to be demonstrated quality learning outcomes. Evaluation involves: establishing benchmarks and performance indicators; measuring and diagnosing learning outcomes; and identifying problem areas and remedial measures. Possible evaluation tools include student surveys, peer assessments, direct observation, audio/video recordings and student field journals.

Conclusions

Field-based learning in the geosciences is essential. The educational benefits of learning in the field far outweigh any inconvenience or apparent higher cost of delivery. Staff, students and educational administrators must be made aware of these facts. However, field-based learning programs need to be properly integrated and linked with other parts of the curriculum and they need to be made as efficient as possible. We need to counter the mistaken perception that field classes are "holiday trips" or "junkets". Demonstrated quality outcomes are the best argument for maintaining and attracting additional resources.

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The Bay Area Earth Science Institute: A Proven Model For Teacher-University Partnerships

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In spite of an inherent human curiosity about rocks, volcanoes, severe weather, and meteors, earth science has traditionally been poorly represented in American schools. The Bay Area Earth Science (BAESI), a comprehensive program for teachers of grades 4-12, was established in 1990 to provide fundamental earth science concepts and strategies for teaching them. A non-profit organization funded by the National Science Foundation, San Jose State University, Chevron Corporation, and a consortium of community partners, BAESI promotes earth science, with its multidisciplinary approach and relevance to everyday life, as a powerful tool for bringing science to all students. To date, 263 teachers have participated in the full program and more than 800 have attended evening and weekend workshops.

Key elements of the BAESI model, which is based on nine years of experience, include 1) a two-week summer program that delivers equal parts science content and classroom applications 2) a comprehensive academic year follow-up program, 3) a teacher leadership program, 4) an on-site Earth Science Resource Center from which any teacher may borrow a wide array of teaching resources, and 5) close ties with partners in government, industry and academia. Participants receive a stipend and university credits which may be applied to graduate programs in education and natural science.

BAESI responds to the disparity between the rapidly growing importance of earth science in the American public school curriculum and the reality that few teachers are prepared to teach it. In the United States, earth science has traditionally been relegated to the shadow of chemistry, physics, and biology. Typically, earth science is reserved for less capable students who are not expected to attend college. National recommendations for science education reform, including the National Science Education Standards (National Research Council, 1996) have, for the first time, placed earth science on a par with the other sciences. However, this change in standards will have little or no impact if earth scientists do not act now to provide teachers with the appropriate background, skills and resources for teaching an effective earth science course or integrating earth science with other disciplines. The gap between external recommendations and the everyday classroom is captured in remarks made by a high school teacher applying to the 1999 BAESI program: *"As incompetent as it may sound, I am applying to the Bay Area Earth Science Institute Summer Workshop because I am a high school teacher who has never taken a single earth science class. To make matters seem even more horrifying, I teach an Integrated Science Course and as my students were learning about leaching, the Coriolis force, and metamorphic rocks, I was learning with them... "*

A partnership between teachers and the faculty in the Department of Geology at San Jose State University is at the core the Bay Area Earth Science Institute. San Jose State University supplies release time for BAESI Co-Directors, classroom and office space, field vehicles and equipment, and technical support.

The success of the Bay Area Earth Science Institute illustrates the importance of a mutually respectful exchange between teachers and university faculty. This two-way collaboration allows each to contribute unique strengths to the creation of a learning experience that is tailored to the needs of teachers and students and is responsive to curricular and logistical realities at the school, district, and state level.

Content knowledge alone is not sufficient to enable teachers to teach earth science. The demands on a teacher's time often preclude the luxury of learning to satisfy personal curiosity, and effective teacher enhancement programs must recognize the need to furnish ready-to-use classroom activities and resources. BAESI responds to this need in two ways 1) teachers are involved in every stage of planning for BAESI initiatives and 2) Lead Teachers, recruited from previous summer workshops, are invaluable members of BAESI's instructional staff. Lead Teachers provide a bridge between the scientific content knowledge that SJSU faculty can supply and the needs of classroom teachers by modeling grade-level appropriate lessons and teaching strategies.

Professional external evaluation has shown that the Bay Area Earth Science Institute has met its goal of improving the quality and quantity of earth science education in area schools. An unanticipated and welcome outcome has been the impact of BAESI on the teaching practices of the university scientists. As a result of their involvement with the Bay Area Earth Science Institute, SJSU faculty have revised their own teaching styles to include more project-based learning, collaborative group work, and guided inquiry.

University faculty anywhere can implement many elements of the model developed by the Bay Area Earth Science Institute. If large-scale funding is not available, evening or Saturday workshops for teachers, tours of geoscience departments for students and their parents, classroom presentations designed to give students an idea of what earth scientists do, and local field trips are inexpensive ways to reach out to local schools. However, to increase the likely success of such outreach efforts, the first step should be a survey that identifies the needs and wants of teachers.

For more information about the Bay Area Earth Science Institute, visit the BAESI home page at http://www.baesi.org or send e-mail to BAESI Co-Directors E. Metzger (metzger@geosun1.sjsu.edu) or R. Sedlock sedlock@geosun1.sjsu.edu).

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Interactive Geology and Geophysics for the Grade 5 to 10 classroom

John Mignone.

Primary Industries & Resources SA
Education Services
GPO Box 1671 Adelaide 5001
Geophysical Technical Services Glenside SA

Explore modern society's reliance on geological resources, mineral and petroleum search methods, mining engineering, environmental management and more applications of geoscience using a multi media approach. This interactive approach will also place at your finger tips topics such as careers, groundwater, energy and explore issues such as what is the right balance in sustainable use of resources. The games, experiments and activities have been designed for enjoyable education, but reflecting cutting edge practices in the geosciences. Participants will be given a complimentary CD ROM used for the workshop.

I also have a thing about fossils! In fact a whole shed full of fossil things! Children love to get their hands on fossils, but too often they are too rare and fragile to handle. See how you can make your own fossil copies for hands on activities to teach children about age dating, correlation, dinosaur's eating habits, how they walked, did they ever get dizzy and how radiation can reveal where they are buried.

The Canadian Geoscience Council and its Role in the Evolution of Geoscience Outreach and Education in Canada

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The Canadian Geoscience Council is a non-profit organisation created in 1972 and currently housed at the University of Waterloo in Ontario. At the turn of the millenium the Council (CGC) represents approximately 10,000 Earth scientists from 12 different member societies. In addition representatives also attend the Council from both Federal and Provincial governments, the Royal Society of Canada, from academia (the Council of Chairs of Canadian Earth Sciences Departments) and from the recently created Canadian Council of Professional Geoscientists. The latter is a now fully-independent off-shoot of CGC. Most recently representatives from the Prospectors and Developers Association of Canada and the Canadian Meteorological and Oceanographic Society have also attended Council meetings.

Although the CGC was created to act as a liaison body between working geoscientists in Canada (largely represented by members of the learned societies and government scientists) and the Federal government, one of its most important roles was, from the outset, geoscience education. The original constitution lays out one of the primary aims to: "*Promote scientific awareness and education in Canada and encourage talented young Canadians to consider careers in the Earth sciences.*"

CGC managed this by establishing EdGEO as an integral part of the Council's activities. This was the first major attempt to promote geoscience education amongst school teachers in Canada. EdGEO activities commenced in the early 1970's and have continued to date. Because CGC was, until 1998, an entirely voluntary organisation, outreach activities could only be formulated and initiated by Council. For these to succeed and grow they have had to become quasi-independent or fully independent of the Council. EdGEO, for example, now runs under the aegis of the Canadian Geological Education Network and involves the training of all teachers, not necessarily just Earth scientists, in critical areas of the geosciences. Past activities have included talks on paleontology and field trips into the Badlands and foothills of Alberta; meetings associated with the Winnipeg Natural History Museum, and a number of sessions organised for teachers through the University of Waterloo. In 1989 EdGEO activities commenced in the Maritimes, and they now encompass all of Canada.

The expectations and scope of EdGEO activities are expanded on by Eileen Van der Flier-Keller elsewhere in this volume.

In 1993 CGC created the Canadian Geoscience Education Board to coordinate and increase the educational role of the Council's constituent societies. In 1995 the Board was renamed to become the Canadian Geoscience Education Network.

CGEN is concerned with all levels of geoscience education in Canada and encourages activities designed to increase public awareness of geoscience. The Network exists to stimulate the development of geoscience awareness activities in Canada and to coordinate the efforts of the Canadian geoscience community in matters related to geoscience education and public awareness of geoscience. It also acts as a forum for discussion of matters related to geoscience education in Canada. Since programs related to education in schools are best delivered on a local scale, CGEN is a collective of grassroots activists who deliver programs in their local areas. CGEN undertakes initiatives that can only be conducted on the national scale and raises funds to support grassroots activities.

CGEN has been responsible for a number of interesting initiatives. For example in 1995 it helped to produce an attractive booklet, *"THE PAST [Public Awareness of Science and Technology] is the Key to the Future"*, as a joint production of the Network and the Geological Association of Canada. This was widely distributed to officers of the constituent societies of CGC. Written by Ward Neale and Louisa Horne the booklet provides essential information for geoscientists who are considering getting involved in the public awareness of science, especially through education systems. A French version, completed by Pierrette Tremblay and Michel Bouchard, is also available.

CGEN has also been responsible for the promotion of *EarthNet*. *EarthNet* is a virtual centre of earth science resource information and contacts for teachers, home educators and students of all levels - elementary, junior and senior high school. It is an Internet directory of (largely) Canadian resources available for those who teach Earth sciences. Graham Williams, Jennifer Bates and Kevin Coflin (Geological Survey of Canada Atlantic) produced a subject category searchable version of the guide in 1996. Teachers were consulted about appropriate subject headings outlined below.

Earthquakes, dinosaurs, fossils, evolution, volcanoes, landslides, rocks and minerals, plate tectonics, mountains, canyons, caves, rivers, waterfalls, conservation, the greenhouse effect, global change, oil and gas, energy, mining, ice ages and glaciers, faults, erosion, geological time, planets and space, geoscience careers etc., can all be searched by topics. The principal search areas are by:

- Earth science topic
- resource type
- geographic region
- grade level
- resource title

A description of each resource, the publication date, cost (if any), and most importantly, the contact organization name, address, phone number and URL are provided once a search has been activated. Examples include:

- Search for Teaching Resources
- Classroom Activities
- Geology in the Classroom
- Glossary of Terms
- Calendar of Events
- Earth Science Site of the Week
- Other Earth Science Websites at Natural Resources Canada
- Other Interesting Earth Science Websites

A Teachers' On-Line Forum is planned.

The CGEN's *EarthNet* Web Site is at:

http://agcwww.bio.ns.ca/schools/esrc/esr-home.html

Less than a decade after the formation of the Council several booklets were produced to help students pursue different career paths. These encompassed careers in the Geosciences and careers in Geological Engineering. In the last decade this tradition has continued and CGC has created four editions of a booklet entitled *"Explore Careers in Geoscience"*. The 54,000 copies produced in the various print runs since 1990 are in both official languages, and provide timely advice for students on careers in geological engineering and in the geosciences.

In 1997 Council authorized a CD-ROM production of 5,000 copies *of "Careers in Geoscience"*, and an Internet version was also placed on-line from the CGC Home Page, currently at:

http://www.science.uwaterloo.ca/earth/cgc/cgc.html but soon to be replaced with:

http://www.geoscience.ca

For the past decade CGC has also been actively liaising with the American Geological Institute (AGI) since many of the problems faced by Earth scientists in Canada are also present in the larger North American context.

The most recent (and potentially the most exciting) venture is CGC's participation in Earth Science Week, scheduled from October 10 to 16, 1999. Julia Jackson, Earth Science Week Program Director at AGI, discusses this AGI initiative elsewhere from an American perspective.

In Canada 1999 will represent the first year that CGC has become involved in this activity and it is hoped that the respective Member Societies will be involved in a number of local initiatives. CGC has distributed 5,000 copies of the Earth Science Week poster across Canada. The week coincides with National Science and Technology week and this may or may not help in the promotion of the venture. Certainly the branches of the Geological Survey of Canada hope to take advantage of this coincidence of timing. Overtures have also been made for the promotion of Earth science books at one of the national chains of bookstores across Canada.

CGC hopes to expand this and other educational activities as we enter the new millenium.

Research-like Experiences in the Undergraduate Classroom: Developing Life-long Learning Skills using Geologic Problems in the Local Environment

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In the United States it is becoming more and more apparent that students are entering their post-secondary educational experience with a vague understanding of the importance of science but little knowledge of how science works and what scientists do. Concomitantly, these students are poorly prepared in the life-long learning skills which all educated citizens must have to succeed in the 21st century. I speak here of the skills of quantitative reasoning, analytical writing and speaking, and critical reading and problem solving. Moreover, it is clear that many students no longer have the ability to learn science using the traditional methodologies of a decade or more ago. Content-laden lectures, no matter how inspiring the lecturer, no longer produce the desired competency in the students. Traditional laboratory exercises in commercial manuals are seen as boring and irrelevant. Today's students are more kinesthetic than auditory learners requiring a decidedly hands-on approach to learning and understanding. It is not surprising that employers in all business sectors but especially in the geosciences demand and seek out employees with more general quantitative and communication skills as well as the ability to think critically, problem solve and organize effectively as individuals and in teams. As indicated in surveys of geoscience employers, broad geologic knowledge and significant communication skills are more desireable than specialized training.

The challenge for undergraduate geoscience educators is to develop curricula which work equally well for the training of science-literate citizens who must be exposed to the methodologies and relevancy of scientific thinking and those who will go on to be hired as geoscientists. In the face of an ever increasing canon of knowledge in the geosciences and the need for significant training in the related sciences and mathematics, this challenge become particularly problematic if we continue to use the traditional ways of teaching. Here I will describe with examples, an approach to teaching geology which has been developed in our department at Dickinson College over a fifteen-year time period. We call it "Research Across the Curriculum". This approach is enriched by parallel Writing and Quantitative Reasoning requirements at the college.

We use this approach for all students at all levels in our program including those who will only take two introductory classes to fulfill college graduation requirements. While the breadth of geologic content is reduced by necessity, the integration of non-disciplinary skills (writing, critical thinking and reading, and teamwork) with problem solving of practical geologic scenaria has proven to prepare all our students for their careers in or out of science.

As the term "Research Across the Curriculum" implies, our approach is one of progressive research activities starting at the introductory level and proceeding through the upper-level required and elective courses to the senior independent research project. Through the course of a student's tenure in our major, he or she will be exposed to an increasingly sophisticated series of data sets, disciplinary and non-disciplinary skills including state-of-the-art instruments, and basic texts to primary literature. Problem solving is emphasized in every course.

At the introductory level, we have students enter into "research-like" experiences. These are well controlled experiments whereby the students collect simple data sets with well known conclusions (for the faculty at least). The students must carefully analyze and synthesize the data and write a short (2-3 page) research paper defending the relationships they have developed from the data they have collected. One of the most successful of these projects involves the students' understanding of surface hydrologic processes in the context of the hydrologic cycle. After a short lecture on 1st principles of stream flow, the students measure the discharge of a local stream. This is done in teams along the same reach of the stream. The discharge (Q) calculations for all teams are compared and invariably one group has made a significant error in data collection or calculation to cause a difference in their value of Q. A discussion ensues on the possible causes of error given that in theory the Q values should be very similar. We then ask the student to calculate the flood stage Q of the stream given what they know about the shape of the channel and the average flow velocity. They then compare their flood stage estimate to a real five-year data set for the stream they have been studying and find that approximately twice yearly the stream floods the adjacent flood plain. This leads to a discussion of land-use planning on floodplains, a very practical and relevant subject for these future homeowners. Upon further analysis of the data the students see that flooding does not occur at the same time every year. We want the students to understand the forces which cause changes to the stream over time so we also include five-year data sets of precipitation, snow on the ground, and maximum and minimum temperature. They are asked to develop 4-5 relationships between the discharge and the climate parameters citing specific events in the record. They must also note any exceptions to the relationships they infer and how the exceptions can be explained using specific events as evidence. This exercise and resultant paper help them to see beyond the river processes to the effects of evaporation, groundwater baseflow and storage and vegetation on the river discharge. They are encouraged to write multiple drafts in order to further distill, organize, and concisely communicate their hypotheses and evidence. Because 90% of the students in these introductory classes will not take another science course we are more concerned about non-disciplinary skills than encyclopedic knowledge of physical geology. Consequently, we give them several more opprotunities to gain practice in observing for detail, describing with accuracy, inferring from observations, discriminating good from bad data, thinking critically, and communicating with clarity.

In the upper-level required and elective courses we turn more to content but continue to stress life-long learning skills in more sophisticated ways. Here, research projects are appropriate to course content. Data sets are more quantitatively complex. Statistical and computer analyses are more fully developed. Some data may be collected using analytical instrumentation at the students disposal. Presentation of results is more varied with debates, simulations, and poster sessions frequently employed. The primary literature is used in directed discussions and for justifica- tion of approaches to data sets or to introduce the problem. In the highest level courses, students are allowed more free rein on the topic and approach to the problem they choose to study. Frequently the problem has never before been investigated and can lead to presentation of results at department symposia or national and regional geologic conferences. Projects can take many forms including those which are continued from year to year and build very large databases (e.g., long term hydrogeochemical and geomorphic studies), those that are the teaching venue for the entire course (e.g., structural and petrologic studies), those that are simulations of geologic or environmental problems (e.g., land-use planning studies with GIS), or those that are related to faculty research interests. Overwhelmingly, the projects are developed around local geologic processes.

A recent example is the study of a large outcrop of quartz-pebble conglomerate which was deformed during the last Appalachian orogeny. The pebbles have been stretched with significant cleavage development. The basics of simple and pure shear are introduced but much of the detail is learned in the field through careful data collection of the long and short dimensions of the stretched pebbles, the brittle extension of tourmaline crystals within the quartz pebbles, and the establishment of Rf/φ relationships.

As one might expect there are both benefits and drawbacks to this approach to teaching geology. The benefits are that the students become geologists. They do what geologists do and learn about all the frustrations and rewards of doing research. They are dealing with real-world problems which speaks to the relevancy problem so many students demand. Their non-disciplinary specific skills are vastly improved and they are thoroughly prepared for their first attempt at independent research. The downside is that content is sacrificed even if there is much greater depth to what they do learn, the project approach is time consuming for the faculty member and student, and there is some difficulty in evaluating students.

Assessment of this pedagogy is a challenge as it does not lend itself to traditional testing methodologies. Progressive teaching requires progressive assessment so that the teacher can respond to problems but give the student enough leeway to step out and be creative. We have opted for progressive assessment over outcome assessment only because it allows so much more constructive feedback to the students as they learn content and the process of doing research. With paper re-writes, problem solving, and critical reading of the literature, it is possible to gather portfolios of the students' work to assess overall progress across the semester. Mid-term and final exams are frequently "provocative" requiring the students to use all the skills they have developed over a semester. There is considerable evidence that this approach is working successfully. Our senior research projects are always accepted for presentation at professional meetings, students have been offered jobs after an impromptu writing test at the interview, and graduate school advisors frequently comment on the maturity of our students' research abilities.

Finally, there are some aspects for success which should be heeded if this is to be adapted for other academic situations:

- Plan Ahead - The project must be well thought out as to logistical viability and student interest
- Give students ownership of the project (planning and outcomes)
- Do not overestimate students' knowledge of scientific research methodologies or even how to develop a testable hypothesis.
- Have a clear schedule of deadlines to finish data collection, analysis, synthesis, and write-up
- Build in lots of extra time

Educating Geoscience Educators: The UPCB Experience

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The heightening awareness of the essential role of science education as a basic component of science and technology literacy is manifested in the concerted efforts in teacher training. Mass trainings have been conducted under the Science Development Program. Certificate and diploma programs for science and math teaching have been conducted under the project dubbed as Rescue Initiatives in Science Education. Professional organization have also conducted regular seminars to upgrade teaching qualities of members. Despite all these efforts, the dearth for qualified teachers, especially in the geosciences, remains.

In high schools, Earth Science constitute a small portion of the subject Science and Technology I. In special science high schools, it is additionally taught as an elective course. Most programs of teacher training institutions are geared towards the teaching of Chemistry, Physics, Biology and General Science, where Earth Science is incorporated. As a consequence of their academic preparation, high school Earth Science teachers possess only the limited background in handling such courses or topics. In the conduct of teacher training seminars/ programs by government-sponsored institutions and professional or private organizations, Earth Science is seldom emphasized. The situation is not also helped by available textbooks, most of which are written by foreign authors who employ a language and examples, both of which are difficult to understand and appreciate.

Realizing that geoscience education is a specific basic component of science and technology literacy, members of the UPCB academe have taken the initiative to conduct summer institutes which are principally aimed at subject content enrichment. Week-long seminars engage secondary and tertiary level Earth Science teachers, most of whom are from the Cordillera region. Unlike in other teacher training seminars, the pool of lecturers is composed of professional geologists and UP faculty members who have conducted scholarly researches in the various fields of geology and in the geographic vicinity of the Cordilleras. The unifying theme concerns the geological principles and processes involved in the formation of the present-day local environment. The tone of presentation is generally non-technical and popular. The main methods of instruction adopted include lectures with hand-outs, hands-on laboratory exercises, guided film showing, field lectures on selected nearby outcrops, and museum and mines tour. To facilitate understanding, some activities are conducted in the local language. Continuing concerns and developments about geoscience education are also tackled. These teacher training seminars proved to be a great learning opportunity not only for the teacher participants, but also for the geologist-lecturers as well. The initial feedback is both encouraging and inspiring.

Geology as a tool for Improving Scientific Thinking Skills

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Scientific inquiry within the geological sciences has a unique characteristic, which differs from classical scientific inquiry. This characteristic is derived from geology's involvement with "experiments" that were conducted millions of years ago by nature. As a result, many geological inquiries are of a retospective type – trying to unravel what has happened in the past, using "fingerprints" left on the earth. Conclusions derived from geological inquiry might seem extraordinary or even imaginary in the eyes of a non-geologist (for example the rising of mountains above the sea, or the shifting of continents). Thus, it is very important that students are able to distinguish between direct observations, observations taken from secondary data sources, conclusions, assumptions and hypothesis.

In a learning program that we have developed, we use this retrospective type of inquiry, to enhance Junior-High school students' general scientific inquiry skills. "The Rock Cycle" is a 30-hour learning program focusing on geological processes, which transform the materials within the crust of the Earth. Each of these process, magmatism, erosion, sedimentation, precipitation, metamorphism and tectonic movement is learned in an inquiry method. The main sources for this inquiry are concrete items, which are natural materials of the Earth, brought to the lab, or studied in the field. The inquiry is performed as a group task, and guided by a booklet, which includes mainly questions, and only a minimal amount of declarative information. In this learning process the teacher mainly act as a mediator by helping the students to use the inquiry method for the investigation of the Earth and its processes. Her or his main role is to make the connections between the students and the scientific knowledge.

Each chapter in the workbook starts with observations, which create a certain cognitive problem. To solve this problem students follow a route of inquiry that have designed for this purpose. Each chapter concludes with a "reconstruction activity", so as to make students more aware of the inquiry route they have just passed through. In these activities students examine their investigation with "scientific inquiry spectacles". This examination includes characterizing the different stages of the activity, using terms like "observation", "hypothesis" and "conclusion".

An in-depth study about the impact of the program "The Rock Cycle" on 7th and 8th Grade Israeli students, showed that students who learned this program improved their scientific thinking skills. A questionnaire specifically developed for this purpose showed that students' ability to identify and distinguish between observations, conclusions and hypothesis has significantly improved. This questionnaire also showed an unexpected gender difference, in which girls were favored over boys, in terms of scientific thinking skills. Another important result of this study deals with the effect of teaching on the scientific thinking skills acquired by the students. Our results show a very large variance among students who were taught by different teachers, indicating that the quality of teaching is a critical factor - only a constructivistic type of teaching can improve thinking skills, whereas traditional teaching can even cause damage in students' scientific thinking abilities.

Student Responses to geoscience models and simulations at Earthworks, an interactive science exhibition in New Zealand

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Introduction

Acknowledging the impact of technology to our society the responsibility of scientists and educators is to improve knowledge and widen understanding (e.g. Black and Aitken, 1996, Mayer, 1997). New Zealand, as most other countries, is rethinking its strategies to teach science. Since 1993 the New Zealand science curriculum has provided the opportunity for earth sciences to be taught in Schools (Ministry of Education, 1993). As one response to the new challenges, Earthworks – a hands-on earth science exhibition was designed. It was developed under a "Learning Experiences Outside the Classroom" contract with the New Zealand's Ministry of Education. Observations and interviews were conducted to evaluate the impact of Earthworks in regards to how successful the simulations at the exhibition were in enhancing understanding. 47 Students (9-13 years) from different schools and classes volunteered to participate in some focus group interviews (see Figure 1). This paper looks at some of the interesting outcomes and some implications.

This study was particularly concerned with simulations (Hodder in Bell,1997) ; hence, it is important to distinguish between a *model* and a *simulation*. A *model* is a simplified version of reality, what Towne (1993), describes a domain model. Reality describes a complex system. A *simulation* goes a further step as being than a model, for it allows interaction. Interaction means that the exhibit allows interaction. Interaction means that the exhibit allows the asking of questions and the construction of answers. Tansey (1971, p.4) writes that "simulation takes those who take part out of the role of a spectator and moves them into the role of a player".

For this paper three simulations are selected:

Exhibit 1: Rock Fall

This was a simulated rock-fall from a cliff-face. Students were required to re-assemble the three dimensional puzzle. In order to re-build the rock-fall according to its stratigraphic sequence students could use clues from a diorama featuring the major life forms during a geological epoch and compare that with fossils or other indicators of the sedimentary regime that were drawn on the "jigsaw" pieces.

Exhibit 2: Earthquake machine

This was a small house that accommodated up to four seated people, that rocked in a horizontal movement. Students could choose between two different Richter magnitudes, one about 6 (corresponding to the most recent earthquake in New Zealand causing severe surface damage, at Edgecumbe in New Zealand's North Island in 1987) and 7.5 (corresponding to the devastating earthquake in Napier, on North Island's east coast in 1931).

Exhibit 3: Volcano

An exhibit simulated a volcanic eruption. In this exhibit a number of compressible foam balls could be stuffed in a tube (the magma chamber). After they were sealed on top with a plug, the students could pump air in the "chamber" with a piston until the stopper and balls were expelled.

Evaluation

Students were observed while visiting the exhibition. Their behaviour was the main focus for the observation. Behavioural categories included "looking", "reading", "hands-on", and "talking" as well as combinations of the above categories.
Students were also interviewed in small group interviews about four weeks after the visit. The interview comprised three stages:

7. Asking the students if they could remember any particular exhibit (non-stimulated recall).
8. Showing the students pictures of the exhibits and asking them for descriptions of the three "best" ones (stimulated recall).
9. Asking students to match photographs of the results of geological processes (e.g. landslides, volcanic eruptions and earthquakes) with those exhibits remembered.

Results of Evaluation

As expected, exhibits that were noisy like the Earthquake machine or visually impressive like the Rock Fall exhibit attracted students' attention and were amongst the most remembered. During the observation the Earthquake machine and the Volcano attracted students to stay for a period of at least 2 minutes; Rock Fall engaged students for up to five minutes. This effect was certainly controlled in some ways by the fact that it would take for example less time to pump up the volcano than to build up the rock fall jigsaw. However longer viewing times were usually achieved when students would engage physically with an exhibit as well as having some conversation with each other. Exhibits with a high talking/hands-on ratio were usually the ones that were later easily remembered in the interviews.
When students were reminded during the interviews of exhibits by seeing pictures of them, students were able to recall more details of them. Often students' descriptions were confined more to how the exhibit looked and worked, rather than what the exhibit sought to portray.

Specific Comments About Particular Exhibits

Earthquake machine

> *(Girl) that was the earthquake machine and you could choose the type of earthquake where people got hurt,*
> *(Boy) that was the earthquake machine, and you had two different earthquakes a larger one and smaller one, and it shook the room, it shook how it would feel in an earthquake,*

However students often made connections between the exhibits and photographs of the results of geological processes and gave detailed descriptions of the underlying concept. These descriptions often mirrored other concepts and proofed a wider understanding. Students felt comfortable applying geological theories like faulting and folding, uplift, subduction, fossilisation as well as volcanic activity and interconnecting those theories. A majority would use terms like plate tectonics and rock names like obsidian and pumice and they were able to explain what those words meant.

Rock Fall

> *(Boy 1) this was covered in sea and it hit and it went up again and turned into a landmass,*
> *How do you relate that photograph with the exhibit?*
> *(Boy 2) it shows that the plates are moving all the time,*
> *(Boy 1) they are shifting,*
> *(Boy 2) they are floating on molten rock,*
> *(Boy 3) they are going very slowly, and then every 100 years or so they change completely,*

In this particular conversation it becomes clear that the students interpret more than just the picture. They seem to be aware of the concept of plate tectonics and the relative movement of plates.

Volcano

> *(Boy 1) that's the lava driving down the mountain,*
> *(Boy 2) when it erupts it's liquid,*
> *(Boy 1) it's molten rock,*
> *(Boy 2) it pushes up from the volcano and it rises all up and then it slides all down, all the molten rock,*

(Boy1) that's the volcano erupting,
Why does a volcano erupt?
(Boy1) All the pressure and all the gas is being built up and then erupted and then it takes a while to build up again, it heats up the rocks so much they just turn into molten rock,

It appears that students associate things they know with the pictures they see and attempt to make reasonable explanations.

Conclusion

By concentrating on portraying geological processes rather than the results (as seen in the field), the "Earthworks" exhibition took a different approach from the more traditional out-of classroom activities in geoscience education like field trips and visits to geological museums. The study suggests that the visual and physical impact of the simulations helped to get the students gain a wider picture of geological processes and seems to have stimulated an awareness of geological processes.

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Development and Practice of Study program on Geosci-education for 6th and 8th graders at Kyoto City of Japan ---Special reference for teaching program in laboratory at the Kyoto Municipal Science Center for Youth (KSCY) ---

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Introduction

Kyoto is the most famous historical city that population is about 1.5 million located in the Kinki district of Japan. The geological feature is that Pre-Cretaceous accretionary complex rocks and Mesozoic igneous rocks is distributed at the mountain area around the city, and Cenozoic fluvial deposits cover the central basin.

As the Kyoto Municipal Science Center for Youth(KSCY) facilities includes laboratories, a large exhibition room, a planetarium, workshops, audio-visual rooms and outdoor activities spaces. School education system is K-12 for basic and secondary education in Japan. In the KSCY have been providing an opportunity to study science for half a day once a year for every grade student, from 5th to 8th, and for part time high school students since 1969. "The study at center" is a school program of municipal public schools. Mentally or physically handicapped students also participate and are given special consideration. The staff of the center prepare a course of study in each subject aimed at inculcating the students with the "scientist's sprit" as well as assisting independence in their study. Regarding conducting teaching and learning program, material and equipment designed and developed by the staff of the center. Study programs of the center especially in the laboratory have four fields such as chemistry, physics, biology, and earth science.

Earth science programs

Study programs of earth science in 1999 are as follows.

programs in laboratory (120min.)

For 6th graders "The igneous rocks " For 8th graders "Coal and limestone"
programs in large exhibition room (60min.)
For 5th graders Free time and "Dinosaurs" "Movement of the sun and sundial"
"Which is hotter? Desert or Kyoto in the simulation space."
For 7th graders "The movement of sun and Sundial" "Volcanic rocks "
programs in planetarium (60min.)
For 5th graders "One step for the starry sky "
For 7th graders "Constellations and planets"

Development and practice

-Ex. Study program in laboratory field of earth science, deal with coal and limestone.
(1) Background
The purpose in laboratory field of earth science are to develop and practice study program in laboratory, that each students will deal with familiar environment by global horizons and their experience in laboratory will develop at schools and home life. For the section staff feel that is rather difficult job. Variety of field activity are mostly pleasant to students but it is rather difficult to design for the short program in the laboratory.
In addition to that the section staff provide a very short period of in laboratory program for schools, but experience of global space and geological time scale in laboratory activity some time rather boring for a majority of students compare with physics or chemistry. Not only that design of the typical program together with real experience is very difficult matter especially conducting throughout the school year. Kyoto city is a typical urban area, that is constraint to finding real materials for earth science education such as fossils, mineral resources, and interesting rocks.
(2) Coal and limestone
The section staff have been developing and practicing study program every year. For the 1999, we have dealt with coal and limestone as organic rocks. We have considering these rocks are surprising for students to made from creatures. And these have been related to earth environment from a long time period as a system of carbon circulation. And these are related to our modern life stile. And also a coal and limestone possess a lot of fossils which we can observe even by the naked eyes. Fortunately supply these rocks though out the year in Japan.
(3) Response from students
We asked students about coal and limestone by questionnaires. The result was as table1.
table 1. result of questions for pre-program (N=203)

Result of a questionnaires for coal and limestone to 8th graders		
A number of "yes"		
	coal	limestone
Do you know the name?	180(89%)	94(46%)
Do you watch it?	123(61%)	62(31%)
Do you feel it?	65(32%)	40(20%)
Do you know what is used for?	107(53%)	15(7%)
Do you know what is made from?	35(17%)	31(15%)
Have you ever been to collecting fossils or rocks or to mines?		
19(9%)		

Many students know only names of rocks. They have learn the rock's name by the science subject study in classroom. They know the name of coal is more than limestone. In Kyoto city, there is the Museum of Steam Locomotive that is the most interesting place for children. Then they have heard and seen a coal. On the other hand, experience of limestone is only as $CaCO_3$ of chemistry at school subject time.

Contents of Study Program

We have conducted our study program in laboratory for 8th graders as follows. Study program or 6th graders is the most same procedure.
(1) Introduction
(a) General discussion of the earth environment compared with the Mars and the Venus.
(b) Diagnosis about coal and limestone in common.
(2) Out line of activity : coal as a raw materials and the elements and form process
(a) Observation of handy samples three types coal produced in Japan for every student under the stereoscopic microscope. One is Eocene (45Ma) sub-bituminous coal produced in the Taiheiyou coal mine, Hokkaido district. Another is Oligocene (35Ma) sub-bituminous coal produced in the Jyoban coal field, Fukushima district. Another is Miocene (19Ma) lignite produced in the Sirakura coal mine, Gifu district.
(b) Experiment of combustion coal fragments by burner and check the gas.
(c) Experiment of making the charcoal from wood fragment.
(d) Observation of tissue is made soft under the microscope. (Only for 8th graders.)
(e) Watching VTR a state of coal-producing district and a CG of diagenesis.
(3) Out line of activity : limestone as a raw materials and the elements and form process
(a) Experiment of chemical reaction by hydrochloric acid.
(b) Grinding limestone three types produced in Japan size is about 3_4 cm for every students. One is Pleistocene Ryukyu-limestone produced in Okinawa district. Another is Jurassic Torinosusiki-limestone produced in Kochi district. Another is Permian Akasaka-limestone produced in Gifu district. (To

grind is only 8th graders. We prepare 6th graders grinding samples.)

(c) Observation of samples which ground limestone. Identification of fossils in the ground limestone under the stereoscopic microscope through comparing with recent Mollusks and Corals and Foraminifers shell sample and their cross section.

(d) Watching VTR a state of coral reef and states of limestone-producing district.

The synthesize and general discussion with the facts and result of the laboratory activities. And finalizing the value of earth science study.

Finalization of the study

(a) Before start the study, we asked to the students such as "what is the common point between a coal and a limestone?" Most of answered these are "only rocks". During this program, they were find out a coal and a limestone are organic rocks in common and these both organic rocks are related to valuable earth environment.

(b) In case of a coal, students were consider it is just like charcoal because both of images through the stereoscopic microscope, and combustion coal fragments by burner same as charcoal. One of the experiment work, students try to make charcoal from small pieces of wood, then they observe image through the stereoscopic microscope and aware it is quite similar to coal. For the students this experiment easy to get an idea for natural coal production process as an analogy. Among of series of the experiment, these kind of experiment are considerably valuable for students. Most students were excited the experiment of combustion of coal.

(c) On the other hand, observation of tissue which made soft under the microscope is a little difficult for them due to getting basic handling skills which takes time.

(d) By the result of the questionnaire for the 8 th students, the most pleasant activity was grinding the limestone during the program. They want to this simple practice for about 30 minutes. All students also require for observing sample of grinding limestone although that is a little difficult for them to compare with recent biotic shells.

Summary

At summary of this program, the students understand coal and limestone in common related to the earth environment under the discussion with the senior science teacher in the Center. Young students such as 8 th grader in Japan, they are mostly want to discuss as a scientific topics that is big issues for example on TV programs, on newspaper articles.

As the one of general tendency in the school atmosphere recently because of multi-media and large amount information become popular among of young people in the developed country. They have well known that the use of fossil resource has been destroying the earth environment. But this short science program "Coal and Limestone" providing some of interests to them. For them it was impressive experience to aware that a fossil resource has been keeping the earth environment.

By the result of the third international science study of IEA, and also the "Science and Scientists : SAS" study have been point out that Japanese children's the worst response among of participating country on the several questions such as, interest to learn science, science: interesting, easy to understand, useful for everyday life, and important for society.

Since 1969, in the KYSC, have been conducting extra science programs in the four science field. These program might be valuable for teaching science for new generation.

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The Earth System Science Approach in Spain: A need in pre-college curricula and some examples of its application at university level.

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More than most sciences, the Earth Sciences have shown a remarkable vitality during the last third of 20th century. For many philosophers of Science, Geology has been the only scientific discipline to have experienced a scientific revolution since Kuhn's "The Structure of Scientific Revolutions" (1962). Recently, new changes have been added to those of plate tectonics. They have been brought in by the inadequacy of the classic scientific disciplines to face with some of today's major problems related to the workings of our planet. Earth Sciences are better suited than each of the branches to analyse complex situations. This has favored the introduction of the concept known as Earth Systems Theory as the motor of the most important curricular changes.

What degree of importance is devoted to Earth Sciences in the new Secondary curriculum in Spain? Have the profound changes been introduced? Does the proposed curriculum favor the adoption by pupils of a comprehensive theory about the workings of Planet Earth? Could some general thematic threads be devised to orient the contents of an Earth Sciences pre-College curriculum? These are some of the questions to be introduced in this paper.

The new curriculum: a lost opportunity.

The substitution of a curriculum can be brought about by a new understanding of the way pupils learn, or by radical advances which provoke essential changes in the discipline, or else by the evolution of society's criteria about what is relevant and useful for future citizens. Those three criteria are met in the present case, as fundamental advances have taken place in each of the three fields since the former curriculum was implemented.

In Spain, during the 90's, important changes have been made in secondary school curricula. In the curriculum of the Spanish Ministry of Education we find geological contents included in the "Biology and Geology" course of the first term of the Natural and Health Sciences *Bachillerato* (broadly equivalent to the British

'A' level), and in the "Earth and Environmental Sciences" course of the second term of this same branch of the *Bachillerato.* An optional "Geology" course can also be offered in this same term; but, since it is not included in the examination for access to Universities, this is a rather marginal option.

Only two of the six broad topics in the Biology and Geology curriculum are related to geology. The first of the two topics is called "Earth's Origin and Evolution", and deals not only with our planet but with the origin of the Solar System and the geology of the rest of the planetary bodies. The second topic is called "Dynamics and Evolution of the Lithosphere", and it is mainly about plate tectonics. The trouble with the geological contents of the *Bachillerato* is not merely that their presence is almost symbolic, but, that they are unable to offer the pupils a comprehensive view of the discipline and a simple and powerful scheme of the workings of planet Earth. This should be an essential goal of the Nature Sciences Bachillerato, which, besides supplying the pupils with a basic scientific formation, should also furnish them with substantial frameworks that help them to choose among the different possible training options. This should not be understood as a defense of an encyclopaedic geology course, but as an expression of our belief in a global interpretative framework permitting the pupil to establish non-arbitrary relationships among separate bits of knowledge, and also to acquire a logical structure applicable to different contexts and embracing the basic elements of the internal logic of the discipline (Pedrinaci, 1998).

The only hint in the curriculum of a perspective on the workings of the Earth could be the last concept in the second topic, which reads "The Relief Cycle and Plate Tectonics". However, it supports the persistence of the "geotectonic cycle" concept: a concept embracing a continuous sequence of stages of relief formation and destruction. This cyclic approach is not only mechanistic and deterministic (and as such obsolete from an epistemological point of view), but is also "simply inapplicable to mountain building processes" (Anguita, 1990), and hardly compatible with plate tectonics. It is now generally assumed that Earth's history follows neither a cyclical pattern nor a linear one, but a non-reversible, non-linear path, notwithstanding its progressive cooling.

The designers of the *Bachillerato* curriculum seem to have been more concerned with incorporating a number of relevant geologic concepts than in giving the pupils a coherent structure of theories, concepts and procedures valid to interpret the physical environment in a comprehensive way. This structure would be useful as well to evaluate some environment-related social and economic problems. One would hope that this gap had been covered in the course on "Earth and Environmental Sciences"; nevertheless, the encyclopaedic condition of this course, its lack of structure, and the transverse nature of Environmental Sciences determine that the building of an interpretative global framework is not included among their goals. This is, on the contrary, a valid and accessible objective for Earth Sciences.

Present trends to take into account

With plate tectonics as the general framework, four lines can be cited which define the evolution towards the present perspective of Earth Sciences. All four have didactic implications and should be considered in the implementation of a sound curriculum; but the first three are already consolidated, while the fourth one is a now emerging tendency that promises to be highly fruitful.

- From "What is it like?" to "How does it work?". In classic Geology the weight of description was bigger than it is now. In this new stage it is much more interesting to understand the keys of the planet's workings: to realize not only her present and past state, but the causes of her evolution, and the possibility of making predictions about her future as well.

- From Uniformitarianism to Neocatastrophism. Ever since Charles Lyell published his "Principles of Geology" in 1830, uniformitarianism has reigned unimpeded on Geology for almost one and a half century. But during the last three decades, a growing number of investigations have shown that Earth's past is compounded not only of the gradual, continuous processes explained by uniformitarianists, but also of other, sporadic ones defined by their high energy. To explain how the planet works and to understand her history requires to consider both kinds of processes. This new concept has been termed "uniformitarianistic catastrophism" or "neocatastrophism".

- From the antagony between cyclicity and linearity to a model of non-linear non-reversibility. Most epistemologists assume today that neither model is valid to explain the planet's complex history: geological processes recur, but never in the same order, and neither does history. Therefore, there is neither a mechanistic succession of cyclic phases as proposed by Hutton, nor a unidirectional history as postulated by Werner, but a sequence of irreversible changes following a non-linear pattern.

- From Reductionism to Holism. In a most outstanding paper published in 1968, J.T.Wilson took an inventory of Geology's place among the Sciences, and claimed that a revolution had just taken place in Earth Sciences. Then he asked himself: Why is the study of Geology so fragmentary? or, Why are there so few geological investigations at a global scale? To have a global theory has doubtless helped to foster research that considers our planet as a system. On the other hand, the enormous bulk of data from space missions favors the making of comparative studies between the geology of Earth and that of other planetary bodies. We can therefore hope that a general model of planetary dynamics and evolution will be built in the future.

What is the use of Earth Sciences?

The clear deficiencies shown by the *Bachillerato* Geology curriculum may be explained by its designers' lack of knowledge of the usefulness of Geology. This ignorance seems to extend to the educational aspects as much as to the economic or social ones. Most natural disasters are the objects of study of Earth Sciences. In 1998 alone they caused the loss of 50,000 lives and of US$ 77 billion in properties across the planet. Do we need more data to prove the social and economic importance of Earth Sciences?
As for Earth Sciences' educational value, we refer to Grupo Terra (1992), who gave thirty reasons to learn Geology in Secondary education. Later on, King (1998), and Domingo and Sequeiros (1998) offered reflections on the benefits citizens should obtain from an Earth Science education. Some of them (such as problem-solving, formulating hypothesis, selecting and processing information, designing experiments, obtaining conclusions) are shared with the rest of the sciences. Others are specific to Earth Sciences: it is for instance useful to recall that near all the materials we use are more or less transformed minerals. To know them and to be aware of their availability now and in the future is essential for an informed evaluation on potential limitations of consumption, substitution, or recycling.

The bulk of the specific contributions of our discipline is related to its historic essence. This is the reason why (1) it uses specific methods of research and analysis, (2) establishes relationships between time and space, (3) arranges causal sequences, or (4) brings about a time perspective essential to grasp Nature. As Grupo Terra (1992) put it, "Geology (...) is not the only Earth Science: even less is it the only Science of Nature. Nevertheless, it is the only Science which tells us the history of Earth and Nature". Providing this is true, a question is inevitable: Is there any chance of understanding the planet we live on, or of making predictions about her future, without granting Earth Sciences a relevant role in the curriculum?

Three practical examples of the Earth System approach at university level.

Despite the general lack of interest in Earth Sciences in Spanish education and the limited space it occupies in the curricula, some individual educators are trying to use geology to integrate science teaching and to apply the necessary systemic approach to integrate other sciences from or with geology. Some examples of this approach are described below. The experience began in 1991, trying to adapt aims, contents and strategies to disciplines taught in different degree courses.

The first example was a 50-hour course called "Basic Science Subjects" for trainee primary school teachers studying Musical Education, Gymnastic and Sport Education and General Basic Education. There were two groups of 50 students. Our challenge was to choose suitable contents and strategies for this course:

1. What basic subjects would be best for primary school teachers?
2. How could we promote interest in science among future teachers interested in music, gymnastics or basic general education?
3. How could we get the most out of the 50 hours to approach the aims outlined by the title of the course.

The second and third examples involved reviewing the way "Physical Geography" and "Geomorphology" were taught within the Geography degree and replacing the traditional approach with a more interactive one.

"Find the Interactions" was the magic expression that inspired all the student groups and awoke their interest in learning.

The primary school teacher trainees were asked to form groups of 5-6 persons and choose a special subject from a long list. It included the Antarctic, Deforestation, Deserts, *El Niño,* Dutch polders, Monsoons, the impact of salt extraction on the local environment of a little Catalonian village, the Delta of the River Ebro, etc. They were then asked to adapt the chosen subject to a standard research outline. The 30 week 90 minutes sessions were devoted to:

-team discussions to draw up a first outline for their project, consult with their tutor, readjust their project, and so on, as many times as was needed.

-bibliographical research about the subject in the University Education Center library

-research in the daily newspapers and recent issues of science and non-science journals

- distribution and characterization of the specific contribution to the project made by each student: bibliographic search, making of scale models, video displays, drawings and poster making, etc.

-presentation to the whole class of the interactions, according to this presentation model:

1. Subject: Title
2. Ambit: local, regional or planetary
3. Parts of the Earth: lithosphere, atmosphere, hydrosphere, biosphere

4.a) If it's a planetary ambit, describe it, explaining first all the scientific concepts involved and secondly the relations between the phenomena; try to symbolize these relations in a schematic arrow-outline

4b) If it's a local or regional ambit, explain it according to the following order of exposition (whole to parts):

In the Earth as a planet
Situation (latitude and longitude, marine or continental or insular position...)
Insolation, annual variations of the sun's angle at noon
The lithosphere
Plate border or interior, kind of plate border
Relief, orientation, magnitude
Materials, kinds, structure and age
The atmosphere
Pressure and dominant winds
Temperature, Precipitation, Climate
The hydrosphere
Marine currents
Subaerial hydrographic net
The biosphere
Natural vegetation or ecosystems
Interactions
Description of the relations found between everything you have considered
Hierarchic arrow-scheme of the described relations, conceptual map

The Physical Geography students prepared subjects individually. Some examples were: The possible influence of the African rift genesis in the evolution of humans and that of the climate, the possible influence of environmental diversity on the human "races" differentiation, the monsoons, the role of plate tectonics and mantle plumes in the Galapagos iguanas and Hawaian fly diversity, *El Niño,* the Southern Caribbean ecosystems, Peru coastal desert, *Nevado del Ruiz* eruption, etc.

The Geomorphology students prepared the interpretation of the interdependency between past and present structural and climatic components in the landforms in a local example chosen by themselves.

The joint evaluation of all three courses was that the students showed:
-Enormous enthusiasm toward the subject (always of their choice)
-Moderate but sufficient ability to look for and find relations between variables
-A global view of problems, with the capacity to find the existence or absence of links between Earth subsystems: atmosphere, hydrosphere, lithosphere, biosphere
-Awareness of many physical science concepts in the system framework and awareness of the need to learn these isolated concepts to understand the whole.

The problems were mainly related to organization: centralized teaching structures do not yet favor this kind of apparent "disorder". But students learn in this manner because they are interested in the subject, because they see it as a real whole.

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Using Space Shuttle Photographs and the Tectonic Map of North America To Inspire Students To Understand Tectonic Features and Processes

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A plethora of visual aids, electronic or other, are available to educators to assist students in identifying large-scale tectonic features and in learning global plate-tectonic processes. Two highly effective and typically inspirational visual aids that illustrate features and processes related to plate tectonics are 1) photographs of Earth taken by astronauts with hand-held cameras aboard the Space Shuttle, and 2) the recently completed Tectonic Map of North America by Muehlberger. (Shuttle photographs are available for perusal and/or purchase on-line from NASA-Johnson Space Center (http://eol.jsc.nasa.gov, http://earth.jsc.nasa.gov), and the tectonic map can be obtained from the American Association of Petroleum Geologists (AAPG).)

Shuttle photographs and the tectonic map are both powerful and stimulating visual educational tools. Shuttle photos reveal a multitude of features and dynamic events of geological, environmental, oceanographic, and atmospheric importance. They can be used in whatever capacity a user deems appropriate, scientific or educational. In our case, and for this purpose, we use Shuttle photographs to reveal tectonic features and to clarify tectonic processes. The Tectonic Map of North America by Muehlberger clearly displays spatially and temporally the major tectonic elements of the North American continent. (For an educator to use the tectonic map to its fullest advantage, one should read the accompanying User's Guide.) As an example of the utility of the map, Reese wrote laboratory exercises using the tectonic map (southwestern and southeastern sheets) to familiarize college-level geology students with the location, map pattern, and origin of significant tectonic features in the United States and adjacent parts of North America. Both of these visual media illuminate to an awe-inspiring degree and demonstrate with remarkable clarity the products and processes of plate tectonics.

Space Shuttle photographs and the Tectonic Map of North America can be used independently, together, or in concert with other educational aids. Reese used Shuttle photos and the tectonic map together to create exercises for Historical Geology and Structural Geology at Northwest Missouri State. (One could also use them for Regional Geology or Tectonics courses as well.) Also, we commonly use the photos and map as introductory and supporting visual aids for a variety of students, ranging from entry-level non-science majors to graduating geology majors (Reese), and from astronaut candidates in training to Space Shuttle and International Space Station crews (Dickerson). Undoubtedly, these media, especially the Shuttle photos, could be used to teach younger students (grades 5-12) about tectonics and other earth science phenomena. The photos and map can be converted conveniently into color slides and into a variety of paper displays, depending on the user's needs. Development of educational CD-ROM's and websites for educators and the general public is being explored. For the present, if you have a computer connected to the internet, you have access to more than a quarter-million Space Shuttle photographs. As future Shuttle missions take place and as the International Space Station becomes operational, even more photos will be available. Whatever the format and application, we purposefully and frequently use the photos and map to excite and motivate students to learn plate tectonics.

To illustrate the utility of Space Shuttle photographs and the Tectonic Map of North America for teaching global-scale tectonics, we provide a virtual field trip using our home continent of North America. This trip also includes samplings from exercises that Reese uses in various courses at Northwest Missouri State. Western North America (Cordillera and Intermontane West) provides excellent examples of the products and processes of plate tectonics, all of which are documented on the map and in photos. Orogenic belts, subduction zones, large igneous centers, basins, rifts, ancient passive margins, a hotspot track, transform boundaries -- all are readily observable in this region. The purpose of this excursion is to familiarize students, fellow educators, and citizens with the location, map and real-world pattern, time of development, origin, and significance of tectonic features in this region. Also, as revealed from Shuttle photos, boundaries separating tectonic provinces are remarkably sharp and distinct. Several tectonic provinces, each with distinctive characteristics, are readily distinguished from inspecting the tectonic map and from examining Shuttle photos:

1. The late Mesozoic-early Cenozoic (Sevier-Laramide) orogenic belt. What are the two main late Mesozoic-early Cenozoic orogenies, and what were the effects of each? Also, what tectonic settings account for the origin of these features? From the map and photos, students determine that the Sevier and Laramide orogenies affected this region at slightly different times and with distinct deformational styles. One style (Sevier) involves the sedimentary cover only, whereas the other (Laramide) includes deformation of the basement. Students are asked to sketch representative cross sections of the distinctive deformational styles. Spectacular Shuttle photos showing the Canadian foreland fold-and-thrust belt illustrate thin-skin (Sevier) tectonics, whereas other photos show the fault-bounded, basement-cored uplifts and asymmetric, intermontane basins of the Rocky Mountains that are typical of thick-skinned (Laramide) tectonics. Structural contours on the tectonic map reveal basin morphology and sediment thicknesses. The details of the origin of these features remain problematic.
2. Other tectonic elements related to late Mesozoic-early Cenozoic orogenesis include accretionary wedges (Franciscan Complex), accreted terranes (Wrangellia), and magmatic arcs (Sierra Nevada and other volcanic-plutonic provinces). By examining the colors on the tectonic map, which correlate tectonic time-events from continent to ocean, students can relate the formation of these features with opening of the Atlantic Ocean during the Mesozoic and Cenozoic. Students can also contemplate the variety of convergent-margin processes (subduction, terrane accretion, magmatism, contraction, etc.) that affected the region and discuss how they are interconnected.
3. The Colorado Plateau. An uplifted region that was exposed or intermittently covered by shallow seas throughout the Mesozoic, the Plateau was only moderately deformed during the Sevier and Laramide orogenies. The thick Mesozoic sedimentary sequence consists primarily of continental deposits, which impart a distinctive red to orange hue to Shuttle photos of the region. During the Cretaceous, the Sevier fold and thrust belt formed to the west and shed extensive aprons of sediment into the foreland basin (Cretaceous Interior Seaway) to the east. The Plateau is bounded to the south, east, and west by extensional structures and to the north by contractional structures. It is dissected by river systems, most notably the Colorado -- Shuttle photos of the Grand Canyon are spectacular. The boundaries between the Colorado Plateau and adjacent tectonic provinces are observed on Shuttle photos to be abrupt. The presence of the Plateau remains something of a tectonic mystery, stirring up controversy as to its origin and stability.
4. Basin and Range Province. This large area of middle Tertiary to Recent extension is well displayed in photos and on the map. Students are asked to determine when extension in this area occurred based on the age of volcanic rocks and sedimentary fill that occupy the numerous basins. The abrupt western and eastern margins of the province along the Sierra Nevada and Wasatch Front, respectively, are easily observed on Shuttle photos, as are the more diffuse structural elements related to transtension along the western edge of the province (the Walker Lane corridor). Students can determine regional strain directions by noting the prevailing northerly orientation of the fault-bounded basins and ranges. Also shown on the tectonic map are areas characterized by extreme extensional shearing (metamorphic core complexes). Though clearly a product of extension, the origin of the Basin and Range province and its linkage to the San Andreas transform margin remain conjectural.
5. The Rio Grande Rift. Extending from central Colorado to the south and southeast through New Mexico and west Texas into Mexico, the middle Tertiary to Recent Rio Grande Rift offers students a chance to study continental rift tectonics. Long, straight, flat, fault-bounded valleys characterize the rift. Block-faulted mountain ranges lie at its margins, and volcanic centers occur at offsets. In north-central New Mexico (around Santa Fe), the High Plains, Rocky Mountains, Jemez Mountains (centered on the Quaternary Valles caldera), Colorado Plateau, and the rift are in close proximity. Shuttle photographs show that boundaries between provinces are sharp; the changing structure of the rift from north to south can be seen as well.
6. San Andreas Transform Fault System. Examining this late Tertiary to Recent strike-slip fault system provides students the opportunity to study the workings of a transform plate boundary. Shuttle photos reveal clearly and impressively the modern structures. The tectonic map shows these features as well and allows for a generalized reconstruction of the plate margin through time. In greater detail, students can compare strike-slip faults with transform faults and contrast features related to restraining bends versus those associated with releasing bends of strike-slip faults. By using Shuttle photos and the tectonic map, students gain an understanding of the evolution of this transform boundary. Also, by inspecting the tectonic map, a student may ponder the fate of the Baja California peninsula

and wonder if similar processes may have been active during earlier orogenies.

7. Cascade Volcanic Arc. Intimately linked to the San Andreas transform boundary and its northern termination is this active volcanic arc. Students can locate the Mendocino triple junction (offshore northern California) on the tectonic map and readily understand why one part of the active North American continental margin behaves differently than another. They are able to contrast the San Andreas transform margin with the Cascadia subduction zone margin to the north. Although the triple junction is not observable on Shuttle photos, the on-shore manifestations of the Cascadia subduction zone are obvious. Many stunning views of Cascade volcanoes -- close-ups of Mt. St. Helens and oblique views of many in the chain -- illustrate the explosive nature of volcanism and reveal a curvilinear (arc) map pattern.
8. Yellowstone-Snake River Plain Hotspot Track. The North American plate has migrated southwestward from late Tertiary to Recent time. In the course of its migration, the plate is thought to have traversed a mantle hotspot that is now beneath Yellowstone. Aligned volcanic vents of the Snake River Plain and Yellowstone Plateau, which are easily seen on the tectonic map and in Shuttle photos, are interpreted as marking the track of the plate as it passes over the hotspot. Using the tectonic map and Shuttle photos, an instructor is able to place the familiar and fascinating Yellowstone region into a regional tectonic framework. Discussions of other nearby volcanic fields of similar age (Columbia River basalts, Basin and Range rhyolites) and their possible relation to initiation of the Yellowstone hotspot can also be lively and stimulating.

Because Space Shuttle photographs are easily accessed via the internet, they are a potentially valuable, readily available educational tool. Additionally, because they dramatically portray geologic (and other) features around the world, earth scientists from the global community can use these photographs to inspire and instruct. We teach plate-tectonic elements and processes by means of exercises structured around Space Shuttle photos and the Tectonic Map of North America, as in this example from western North America. Whether used separately or in combination, each evokes in students a sense of wonder and curiosity about the Earth.

The Renovation of Earth Sciences at the Palais De La Decouverte, Paris-France

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The program « Planet Earth » has been engaged at the Palais de la découverte since 1995. A new permanent exhibition entitled « Questions about atmosphere » is the first part of this program and it has opened since 1996. It has been set up in cooperation with MétéoFrance, AirParif and research laboratories.

The main idea was to help the public and the scholars to better perceive that human activities are changing our atmosphere and that everybody on earth is responsible for its conservation.

The exhibition is composed of 4 units : Meteorology and prediction, How does the climate on earth work ? What's about the climates on earth in the past ?, Ozone, holes and peaks..In each unit, there are graphs, photos, videos, models or hands-on and texts.

In meteorological unit, the visitors may see « The day today » by direct réception of satellite images from Météosat and temperature measurements from french meteorological stations. There is also a meteorological shelter with running instruments and a model of an atmospheric sounding.

In climatological unit, there is a hands-on on albedo and another on greenhouse effect. The visitors may also use a software entitled « Climates all around the world » and have climatological informations for 4000 cities.

In palaeoclimatological unit, there is a hands-on illustrating the difference between seasons. A graph shows the different periods in the earth history where glaciations took place and there is a detailed study about the Quaternary glaciation. The visitors can see an artificial marine core for the last 40 000 years.

In the unit about ozone, we compare and make clear to the visitors the difference between ozone in the stratosphere and in the troposphere.

The visit of the exhibition may be guided (public or scholars) with the presentation of one unit or the entire room, or unguided.

The second part of the renovation of Earth Sciences rooms at the Palais de la découverte is the subject of another oral presentation.

A New Permanent Exhibition at the Palais De La Decouverte Paris France

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This new permanent exhibition has opened since the end of 1998. The second part of the renovation of Earth Sciences rooms in the museum is entitled « Earth and life, a scientific investigation ». It has been set up in cooperation with many research laboratories.

The idea was to help the public and the scholars to better perceive the great age of the earth. The total length of the room is 70 meters; so with 10 million years for each meter, visitors can visualize the last 700 million years. The rest of the earth history, that is 700 million years to 4.5 billion years, is visualized by a scroll, the total length of it is 450 meters. All around the room, boundarymarks indicate each 10 million years.

The exhibition is composed of 5 units. These units do not correspond to the classical partition of the earth history, that is Praecambrian, Primary, Secondary, Tertiary and Quaternary eras, but are centered on particular events.

Each unit is characterized by a colour. There are 3 animated models realized by an artist inside 3 units and 2 shows based on slides in the first and the last units. There are also graphs, photos, samples, scientific instruments and texts.

For each unit, the presentation is the same ; on the left the observations, in the middle examples of scientific methods of investigation with different instruments, on the right the theories resulting from the various hypothesis. In each unit, a problem is studied in detail and there is a table showing the evolution of ideas or theories on a specific subject. All around the room, there are big maps of the earth from 700 million years to nowadays designed on the walls.

The visit of the exhibition may be guided (public or scholars) or unguided; in which case, there are many hands-on and 2 CDroms.

The CDroms deal with the different methods to date geological events , and the life in Primary oceans.

The hands-on consist in reconstructing palaeogeographical landscapes from rocks, either synchronically (same period, different locations) or diachronically (same location, different periods), recognizing fossils, answering questions on the requirements of aerial living for plants and animals, and listening to well known french palaeontologists on the causes of the extinction of dinosaurs.

The most interesting thing we can show and explain in this exhibition is the links between different elements : the moving of the continents and the plate tectonics, the building of the mountains at different times, the biological extinctions and their different causes, the different climates a continent has suffered during the last 700 million years.

Another aim of the exhibition is to show that research is still going on ; all along the room, we present the most recent discoveries which have pushed back in times the date of the most ancient fossil ever found.

Young visitors can be led through the exhibition by « treasure hunts » on mountains and climates, consisting of a serie of questions leading them to various exhibits.

We are now preparing a special tour for blind visitors.

The third part of the renovation program is on the way and is on the theme of the dynamic earth

Eyes in Stone....or, what the trilobite saw and other lessons of life long ago.

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Palaeobiology, the science of life in deep time, is very much more than the acquisition and reconstruction of dinosaurs for museum displays. Fossils reveal a convoluted history of life that reaches back nearly 4 billion years, with as many plot twists, catastrophes, and bizarre characters as a Hollywood disaster epic. The fossil record is our concrete connection with life of the past and because of our universal fascination with things that have gone before, it provides us with endless opportunities for enlivening classroom studies, not just within an Earth science context, but across a broad educational spectrum. Many kinds of invertebrate fossils can be easily obtained with little or no expense and make safe, durable additions to classroom resource kits. Casts, models, images, and other reproductions of less common or more fragile fossils are also widely available. Simply having such materials present in a classroom environment is a stimulus to discussion and thought and it is a relatively simple matter to extend their utility beyond objects of wonder. In addition to serving their traditional and crucial role as the documents of organic evolution, fossils can be employed for everything from simple shape/pattern recognition (trilobite puzzle matching) for junior or primary students, to illustrating complex mathematical concepts (hexagonal close packing in tabulate corallites, or the Fibonacci sequence expressed in shell coiling) at more advanced high school levels. Students of all ages are captivated by the notion of life in deep time and despite, or possibly because of, the often unfamiliar appearance of many fossil organisms, they respond well to the conceptual problems that such materials pose. For instance, fossils provide a simple and expedient introduction to the whole concept of Earth's dynamic history, by engendering straightforward, but challenging questions like, "Why do we find the remains of obviously aquatic organisms in the middle of modern deserts? What does this tell us about our apparently stable and static planet?" Tried and true hands-on instructional activities, such as making casts, moulds, and impressions to simulate fossilization processe and explain modes of preservation, can easily be augmented with more elaborate exercises involving zonation and correlation puzzles to illustrate the biostratigraphic utility of fossils. Virtually any lesson in a standard elementary biology curriculum (classification, biodiversity, growth and change) can be enhanced by the integration of fossil materials in an ancilliary supportive role. Challenging students to reconstruct ancient environments by "looking" into the past through the eyes of an extinct organism can be an exciting way to develop basic ecological concepts. Trilobites, in many ways as exotic and intriguing as dinosaurs, become particularly useful silent witnesses in such an exercise. What *would* trilobites, with their prominent compound eyes, have seen in the seas of half-a-billion years ago? The notion that dinosaurs and other fossils can be used as "hooks" to capture students' interest in the broader spectrum of Earth sciences is, in itself, hardly a novel proposition. However, with a little creativity and some simple resources fossils can open the doors to many other worlds of wonder.

Designing An Interactive, Transportable Exhibition on Geology and Mining Industry

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The background

Studies and developments in Didactics of Geology are scarce (if any) in Argentina. This situation is evident at different levels:

a- The absolute lack of formation of primary and secondary school teachers in this discipline. Geosciences have been absent from the Curricula until very recent times. Several isolated issues were laterally covered in Geography and Biology courses, but this methodology has proved to be inadequate. Oversimplification, deformation and decontextualization of the concepts (disciplinary content) were the most common result.

b- Although most of the books used in school are written in Argentina, the lack of local examples is observed significantly. This problem is emphasized by the fact that some books are just translated from foreign languages by non-geoscientists.

c- The insufficient budget devoted to the improvement of teachers' knowledge on geosciences and to organize field trips programs. Strong efforts have been recently started to provide schools with geological education kits including rocks and mineral samples and give teachers instructions about how to use these materials.

Expominar

Expominar is an interactive exposition of highly visual impact designed to popularize basic geologic concepts and aimed to introduce citizens of different ages to the complex world of mining industry. It is designed and planned to travel through the country during the next years. The first presentation of this exposition was in Buenos Aires (Argentina) in November 1998.

Advanced university students of the career of Geology of the University of Buenos Aires performed as guides giving information and helping guests in their visit.

Goals

The main goal of the exposition is to give visitors not only information about geology and mining industry, but also basic geological concepts involving different methods and strategies as well. Visual attractions like sculptures, 3D models, mural paintings, mural maps and large photographs are used. This exposition was conceived as a place where teachers, students and common citizens could make their first "hands-on" approach to many geological issues that they only had the chance to read in books or to see in videos.

Contents

The evolution of the Earth, the main rocks and minerals' features, their physical and chemical properties, which are relevant in exploration and industrial processing, are emphasized using murals, models and samples. Also the main structures that link to ore mineralization bodies are shown. The different processes that run from the identification of ore deposits, to the evaluation of their economic potential, the extractive techniques, the environmental considerations and industrialization are illustrated using scale models, photographs and dioramas. Interactive activities are used both to grasp the attention of the visitors and to further illustrate several geological, physical and technological concepts. The most impacting objects in the exhibit are a natural scale reproduction of a twenty-five meters long mine and an open pit mining´s model (measuring 12 meters long by 6 meters width by 1.5-meter depth).

The exposition is divided into ten different thematic modules (actually tents) and covers and integrated surface of about 1.500 square meters. The tents can be arranged into different ways in order to fit in any particular place. Although a path is suggested to follow the exhibition, the visitor can move freely around the tents.

The thematic contents covered in each module are:

1. *Minerals in every day life.* This area aims to prepare the visitor for the rest of the exhibition giving him an unusual view of every day materials in the form of sculptures and murals and asking several questions that will find their answers throughout the visit.

2. *Earth's interior and crust: Structure and Materials.* This second tent shows a large panel (14 meters long by 2.40 m high) displaying earth's inner structure, the basics of plate tectonics and the most common geological structures. In the same area, physical and chemical properties of minerals and basic crystallography concepts are displayed and explained. Many interactive

activities like mechanisms of folding strata and comparison of common minerals' density are proposed.

3. The third tent is devoted to the relationship between *Man and Minerals.* The main attraction is a video projection referring to civilization's evolution, the role of minerals in the development of mankind and how it's search has affected human beings.

4. In the following area, named *Searching for mineral deposits* the visitor is introduced to the main aspects taken into account during field geology work and mineral prospection planning. Special attention is given here to geological mapping, aerophotography and geophysical methods in prospection.

5. Once a mineral deposit has been recognized, further studies have to be done to decide its economic potential. This is the target of the next tent, *Evaluation of mineral deposits.* As long as they are part of the large economic equation, environmental impact concepts are introduced at this point and are taken into consideration in several of the following modules.

6. *The mine.* Once mining is determined, several methods may be chosen according to ore deposits characteristics. Although underground mining is considered undereconomic nowadays, is still the most popular conception of mining in common people. Two tents have been used to reproduce a mining gallery with all the machinery and light and sound effects necessary to make the visitant feel the real scenery.

7. In shocking contrast with the previous one, the tent reserved to *The open pit* displays a 1:250 scale model of a porphyry copper mining. Here the guests have the opportunity to compare the oppressive sensation of the gallery with the vast scale of a large diorama reproducing a mountain landscape and the large hole surrounded with small houses and trucks that give the necessary anchor to human dimension.

8. *Processes and transformations* is the title of the following module. Here the visitant enters to the world of mineral concentration processes. In the same area a special diorama linking to gold, its properties and several curiosities of gold mining history is displayed. In this tent several interactive games illustrate different methods of separation based on physical properties like shape, weight and other concentration methods.

9. Next and last is the area of *Industrial, minerals and rocks.* Materials that are mined not for metal content but for their technological applications and use as ornaments, building are presented here.

Interactions

As it was mentioned before, "hands-on" interactive activities are displayed in most of the modules. These activities have multiple purposes like provoking recognition and discussion of concepts shown in other sectors of the exhibit.

Extremely good comments from visitors were received about Geology students' advise. Using identifying T-shirts they were present in all the modules. They answered questions, helped with models' manipulation and provided additional explanations to the more inquisitive guests. The kindness of the students and their familiar look certainly played an important role procuring a proper interaction with the visitants.

The working groups

The exposition was commanded by the Argentine Mining Under-secretariat following the primary ideas of a group of artists. Once the project was accepted, it was given to an architect's studio to be put on tracing paper and built up. Until that time nobody had taken into account the details of disciplinary content. Considering the importance to show clear and real concepts of the subject, a group of geologists and science educators was called to cover these aspects. The preliminary project had a strong accent on visual attraction, a feature to be conserved. To avoid misconceptions and to make good use of the possibilities of the exhibit, several of the first proposals had to be redesigned and adapted.

The fact that the exposition needed to be dismounted into small pieces in order to allow transport was a real challenge when designing and building the biggest objects.

The complex task of arriving to the final shape presentation was a product of intensive interaction of three different working groups: artists, architects and geologists. Selecting the topics to be treated as 3D objects, drawings, photographs or texts, preparing the illustrations and the texts to be placed in computers -these computers are located in different areas of the exhibition- had to be achieved by the three groups working in close relationship with each other.

Thematic content and didactic analysis had been the responsibility of the professionals from the University of Buenos Aires, belonging to the Department of Geology and to the CEFIEC (Center for Investigation and Formation in Science Education).

Scenographers, artists and artisans were in charge of the esthetics conception, panels and sculptures. They converted designs and ideas into objects, panels and models, and located them into the stage.
Many technical problems arising from the need of lightness and transportability were resolved by the architects.

The high degree of interaction between these three groups is by far the most important feature to be underlined. Although each of the groups had its own and clear responsibility, in many cases the final conception is the result of a continuous series of changes and modifications in order to adapt the proposal to the technical limitations, stressing the positive values of the scenographic issue and trying not to loose clarity of concepts. Geologists and science educators had to be alert of the danger of introducing misleading interpretations hidden behind attractive presentations.

The necessity to conjugate the disciplinary content (geology and mining) with an emphasis on aesthetic attraction and finding the way to propose simultaneous multiple reading levels for the differently motivated and informed visitors was not a minor challenge. It required a lot of coordinated work between the three groups.

The web site

Another relevant aspect of this project was the construction of a Web site that served as an extension of the exhibit contents and provided additional explanations and information on different items. It also provided links to other related sites in the World Wide Web. Taking into account that the exhibition is programmed to travel to different cities in Argentina, the possibility to have a virtual access to it through Internet brings the opportunity to capitalize the work done. The exhibition's virtual site can be accessed at

http://157.92.20.135/aula-gea/AulaGEA.htm

Conclusions

Designing Expominar has been a challeging and exciting experience for us. It introduced teachers, students and common citizens to the practically unkown world of mining and, as clearly pointed out by general visitors and teachers, it did not missed its point.

We hope that the exhibit fulfills its initial plan to travel around Argentina approaching people to geological concepts in an atractive display that provokes curiosity and motivation to learn more, and that helps the construction of popular geological knowledge.

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Enhancing The Professional Status Of Geoscientists In Australia: The Role of the AIG

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Aims and Objectives of the AIG

The Australian Institute of Geoscientists (AIG) was founded in 1980 as an initiative of the Geological Society of Australia. The AIG was established as a non-profit company, with objectives, among others, of advancing the study, teaching and practice of geological science and of promoting the good standing, identity and reputation of the geoscience professions in Australia. The AIG aims to represent the full cross-section of professional geoscientists, including people both within and outside the extractive resource industries. Geoscience educators are encompassed within the Institute's orbit, as well as geoscience researchers and many other groups such as environmental geologists, hydrogeologists, engineering geologists, geophysicists, geochemists, information specialists and Geological Survey staff.

There is a clear distinction between a learned society, such as the Geological Society of Australia (GSA), which exists primarily to advance geological knowledge, and a professional institute, such as the AIG, which exists mainly to support those in the practice of the geoscience profession. There is also a clear distinction between a discipline-based institute, such as the AIG (or the Institution of Engineers, Australia) and an industry-based institute, such as the Australasian Institute of Mining and Metallurgy (AusIMM). AIG focuses its activities purely on the professional activities of geoscientists, regardless of the industry or commercial field with which they are involved.

Admission Requirements

Membership levels for AIG are Undergraduate Affiliate, Graduate (*GAIG*), Member (*MAIG*) and Fellow (*FAIG*). The basic educational requirement for admission as Graduate or above is a degree or equivalent in geoscience. A minimum of five years professional experience in addition to this basic qualification is required for admission to Member, and 15 years experience together with prominence in geoscience for admission as Fellow.

Changes in geoscience education and the changing role of geoscience in the community are beginning to provide some problems in defining what is meant by *a degree in geoscience*, and what constitutes an acceptable educational qualification for membership. Significant questions include how much geoscience should be included in relation to other disciplines, and what coverage of key geoscience topics is required in a degree to provide an acceptable basis for admission. Applicants may, for example, have completed degree programs where geology is combined with substantial contributions from other disciplines. This is perhaps desirable, and reflects the widening involvement of geoscientists in various cross-disciplinary professional activities. On the other hand it leads to some difficulty in defining what is meant by a *geoscience* qualification.

There is also some debate as to the desirable balance between traditional geoscience components such as structural geology, petrology and field mapping on the one hand and emerging disciplines such as surficial geology, urban studies and computer applications on the other. The AIG does not lay down formal course accreditation requirements, but there will probably be an increased need in the future for inclusion of transcripts listing the subjects completed, along with evidence of the degree itself, in membership applications.

Professional Recognition

Membership or Fellowship of the AIG is required for geoscientists to report formally on matters such as mineral resources and ore reserves to the Australian Stock Exchanges. A similar privilege is accorded to geoscientists who are Members or Fellows of the AusIMM. This provides protection for the investing public, and at the same time enhances the professional status of geoscientists in the Australian community. It also provides a responsibility for the AIG to maintain acceptable admission standards, and to maintain high standards of ethical behaviour amongst its members.

The AIG participates in the Joint Ore Reserves Committee (JORC). The JORC Code (JORC, 1996,1999) has been adopted by the Australian Stock Exchange to set the reporting requirements for resource assessment by listed companies. The AIG is also represented on the Australian Geoscience Council (AGC), a national umbrella organisation of geoscience bodies.

Members or Fellows of AIG may also be recognised as Registered Professional Geoscientists (*RPGeo.*) if they have submitted to a further appraisal including documenting the required period of specific relevant experience and agreeing to maintain a program of continuing professional development. A peer review system and a rigorous refereeing program are also involved in approval of applications for *RPGeo.* recognition. Specialist fields of practice embraced in this additional qualification include mineral exploration, mine geology, coal, petroleum, geophysics, geochemistry, hydrogeology, environmental geoscience, information geoscience and other branches of the geological profession.

A minimum of 50 weighted hours of continuing professional development per year is required to maintain *RPGeo.* status. This may include formal coursework or thesis studies, attendance at technical meetings and symposia, presentation of papers at symposia or in the literature, reading of current technical and scientific literature and on the job training programs.

Continuing Professional Development

As a means of supporting the professional development of its members (and the geoscience profession in general) AIG Branches regularly organise symposia on a variety of topics, often in conjunction with other societies or institutes. These short events typically have a very practical flavour, intending to provide news of the latest technologies in geoscience at low cost to members. Proceedings are published as *Bulletins;* other useful information for practising geoscientists (e.g. a report preparation manual) is published as a *Handbook* series by the Institute. Recognising that many geoscientists are self-employed consultants or contractors, the AIG has also drawn up a pro-forma client-consultant agreement for distribution to members, and provides notes on setting up a personal business in the geoscience profession.

AIG communicates with its members through publication of *AIG NEWS*, a bimonthly newsletter typically around 30 pages in length. It also maintains a web site, which includes information on the institute, news of upcoming meetings and other items of interest to members, students and the general public.

A recent extension of AIG's web site activity has been the establishment of the *AIG Journal*, a web-based technical publication dealing with applied geoscientific research and practice in Australia. Other recent activities include the establishment of an interactive Directory of Australian Geoscientists through the AIG web site.

The AIG also enhances the status of geoscientists in Australia through a range of other activities, including an informal mentoring program, provision of advice in connection with workplace injuries and geoscientist remuneration surveys.

In addition to its role in supporting those in the profession itself, the AIG also assists primary and secondary school students gain an appreciation of geoscience and an enthusiasm to study and understand geoscientific principles. It promotes the role of geoscience in society as a responsible and essential contributor to improving our way of life. The Institute wants to encourage young people to join the geoscience professions and take on the challenge of changing and controlling the future use of resources, and also of solving problems left by the bad practices of the past. Environmental geoscience is a major area of growth for new graduates.

Communication to the public on issues relating to natural hazards provides an important contribution to the health and safety of all citizens. Risk associated with natural hazards (earthquakes, landslides, tsunamis) also has critical significance for the insurance industry and for other important vocations such as tourism and property development.

A vision for geoscience education

The mission of the AIG is to enhance the professional status of geoscientists in Australia. One way to do this is to ensure that the education of all young Australians includes respect and understanding of the natural components of geoscience that surround them. There are many ways to address this in the current education curriculum.

The everyday processes of erosion and weathering, the relationship between geology and landform, geology and climate and geology and the environment are familiar to all geoscientists. Less easy to viualise and communicate are the interplay of earth dynamics, evolution, asteroid impact, magmatic processes, mineral deposit formation, and our social dependence on minerals.

Integration of these exciting subjects with the environmental and life sciences is necessary to ensure that these aspects of geoscience are taught and understood in our schools. By making geoscience education accessible, we can ensure that those young scientists with a natural inclination to study rocks will have their interests cultivated from an early age. A by-prouduct of this process is that there will be many others who develop an understanding and respect for the contribution that geoscience makes towards society. The AIG has a large number of geoscientists who are motivated to contribute to this process and will be pleased to continue to participate co-operatively in such ventures with other organisations. The eduction curriculum at all levels should positively encourage an appreciation of geoscience as a science in its own right, and as a solid foundation for all the other environmental and life sciences.

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The New Curriculum and the Reform of Science Learning

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The purpose of the national curriculum standard reform

1. To help a child cultivate rich humanity, sociality and identity as a Japanese living in the international community.
2. To help a child develop ability to learn and think independently
3. To help a child acquire basic abilities and skills and grow one's own individuality by allowing ample scope for educational activities to develop.
4. To encourage each school to show ingenuity in developing distinctive educational activities.

The design of the fourth domain

In addition to such three domains as subjects, moral education and special activity in the past curriculum in Japan, the new integrated study had been established in this curriculum which will be acted from 2002. "Period for Integrated study"will be established to encourage each school to show ingenuity in providing interdisciplinary and comprehensive courses, including international understanding, foreign language conversation, information study, environmental education and welfare education.

The reform of science learning

The elementary reform standard

Purpose

1 To help students get familiar with nature with intellectual interest and inquiring mind.
2 To help students observe and do experiments with definite purpose
3 To help students foster the ability and attitude to inquire scientifically
4 To help students foster the scientific view and way of thinking

The viewpoint of reform

1 To think highly of learning related with natural experience and daily life
2 To think highly of learning related with natural environments and human beings]
3 To do observation and experiments with ample scope
4 To foster problem-solving ability and multi-lateral and integrated viewpoints

Concrete reform items

(Primary school)

1. To foster the problem-solving ability (comparison of events, abstraction of factors with change, designed observation and experiment, multi-lateral considerations)
2. To fulfill the relation with our daily life (making some matters and natural I disaster)

a._Life and its environments_
Phenomena with real life and growth of flora and fauna
b._Matters and energy_
Character of matters and change of states, and making something
c._Earth and cosmos_
Phenomena in the lithosphere, atmosphere and the terrestrial globe,
Pursuit of these phenomena with viewpoints of natural disaster

(Junior High school)

1. To foster scientific way of thinking and problem-solving ability
2. To develop from learning on the basis of direct experience and observation to learning to foster analitical and integrated viewpoints
3. To fulfill outdoor observation to foster the problem-solving ability
4. To think highly of inquiry activity to solve the tasks.

[The 1st field]
Light, sound and chemical change, electricity, phnomena of motion, energy, and scientific technology and human beings.
[The 2nd field]
Flora and fauna, the change of the land(orogeny), fertilization of life, terrestrial body, environments, natural disasters

(Senior High school)

1. To think more highly of inquiry study.
2. To foster the ability and attitude to inquire the nature
3. To help students foster rich scientific literacy according to the ability and aptitude, the interest and attitude, future plan of students

The new establishment of Basic science
Inquiry and solving the secret on nature, contribution to the development of civilization, realization of the past experiment, the process of task-solving, learning of the problem facing science and the relation between science and human life, fostering the scientific view and way of thinking

The new establishment of Integrated science A and Integrated science B
Integrated science A: learning of inquiring the natural events with relation to our daily life like matters and energy, centering the relation between scientific technology and human beings , fostering the integrated view of nature ,and the ability and attitude to inquire nature
Integrated science B: Learning of inquiring the natural events with relation to life phenomena and earth environments, centering life and its environments, fostering the integrated view of nature, and the ability and attitude to inquire nature

Physics Chemistry Biology Earth Science
To consist of more elementary contents in the current B do observation, experiment and inquiry activity, and learning the basic concept and the inquiry method

Physics Chemistry Biology Earth Science
To do observation, experiment and inquiry activity on the basis of the contents of above subjects, and further developmental concept and learning of inquiry method .
To select the items according to the ability and aptitude, and the interest and attitude of students

Earth System Science in the Community – Understanding Our Environment: An Earth System Science Curriculum for High School

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EarthComm (Earth System Science in the Community - Understanding Our Environment) is the American Geological Institute's high school earth science curriculum project. Supported through the National Science Foundation and the American Geological Institute Foundation, EarthComm targets the grade 9-12 earth science and inquiry standards of the *National Science Education Standards* (NSES). The ultimate goal of the EarthComm curriculum is to provide all students in U.S. high schools with an opportunity to develop and enhance their understanding of earth systems.

EarthComm consists of five modules, each of which contains three community-centered content themes:

Natural Hazards
- Volcanoes and your Community
- Earthquakes your Community
- Plate Tectonics your Community

Environments
- Geomorphology of your Community
- Surface Processes in your Community
- Land Use Planning in your Community

Fluid Spheres
- Severe Weather and your Community
- Cryosphere and your Community
- Oceans and your Community

Earth Resources
- Mineral Resources of your Community
- Energy Resources and your Community
- Water Resources in your Community

Earth System Evolution
- Changing Environments in your Community
- Changing Life in your Community
- The Solar System and your Community

Every investigation in EarthComm centers around a chapter challenge. The challenge motivates students to use a variety of methods and resources while inquiring about a problem or a focal issue in their community, region, or state, including hands-on, data collection and interpretation, video, CD-ROM and Internet-based applications, and media and text-based research. Students are prompted to think about how their developing awareness of issues and science concepts helps them to better understand their community and its connections to the Earth system.

Development of the EarthComm curriculum was guided by ten fundamental ideas that are emphasized in all units and are the primary goals for student learning:

1. **Earth science literacy** empowers us to understand our environment, make wise decisions that affect quality of life, and manage resources, environments, and hazards.
2. **Earth's dynamic equilibrium system** contains seemingly infinite number of subsystems from atoms to planetary spheres. Materials interact and flow among these subsystems due to natural forces and energy flowing through the system from sources inside and outside of the planet. These interactions, changes, forces and flows tend to occur in off-setting directions and amounts. Materials tend to flow in chains, cycles, and webs that tend toward equilibrium states in which energy is distributed as uniformly as possible. The net result is a state of balanced change or dynamic equilibrium, a condition that appears to have existed for billions of years.
3. **Change through time** produced the Earth we now see, the net result of constancy, gradual changes, and episodic changes over human, geological, and astronomical scales of time and space.
4. **Extraterrestrial influences** upon Earth include extraterrestrial energy and materials, and influences due to its position and motion as a subsystem of an evolving solar system, galaxy, and universe.
5. **The dynamic geosphere** includes a rocky exterior upon which ecosystems and human communities developed and a molten interior with convection circulation that generates the magnetosphere and drives plate tectonics. It contains resources that sustain life, causes natural hazards that may threaten life, and affects all of Earth's other geospheres.
6. **Fluid spheres** within the Earth system include the hydrosphere, atmosphere, and cryosphere, which interact and flow to produce ever-changing weather, climate, glaciers, seascapes, and water resources that affect human communities, and which shape the land, transfer Earth materials and energy, and change surface environments and ecosystems.
7. **Dynamic environments and ecosystems** are produced by the interaction of all the geosphere

at the Earth's surface and include many different environments, ecosystems, and communities which affect one another and change through time.

8. **Earth resources** include the nonrenewable and renewable supplies of energy, mineral, and water resources upon which individuals and communities depend in order to maintain quality of human life, economic prosperity, and requirements for industrialization.
9. **Natural hazards** associated with Earth processes and events include drought, floods, storms, volcanic activity, earthquakes, and climate change can pose risks to humans, their property, and communities. Earth science is used to study, predict, and mitigate natural hazards so that we can assess risks, plan wisely, and adapt to the effects of natural hazards.
10. **Stewardship and sustainability** go hand in hand. Humans and communities must understand their dependency on Earth resources and environments, realize their influences on the Earth systems, appreciate Earth's carrying capacity, manage and conserve nonrenewable resources and environments, develop alternate sources of energy and materials required for human sustenance, face the prospect of human extinction, and invent new technologies that foster these parameters of stewardship in order to sustain the presence and quality of human life.

EarthComm was developed within the vision of the National Science Education Standards, a document that describes the systemic nature of science education reform. To this end, the EarthComm project team developed a series of goals and expectations for teachers and students. Curriculum design teacher enhancement, and student learning materials are all developed within EarthComm with the following in mind:

EarthComm Goals and Expectations for Teachers

1. Use motivational teaching methods, interactive technologies, and manipulatives to pique student interest and engage students in constructivist guided-inquiry activities that help them develop knowledge and understanding of practical essential Earth science principles and practices.
2. Have students conduct inquiry-oriented research on local problems and issues that are related to Earth's natural processes, resources, and environments so they learn/reinforce the concepts, principles, and practices of Earth science as they develop an understanding of its relevance in their lives and environments.
3. Integrate Earth science and other high school academic disciplines through a problem-solving, issue-based model. In this model, the teacher assumes the role of facilitator and students carry out inquiry-oriented investigations to seek information and derive reasonable inferences related to authentic questions and problems.
4. Establish an expanded learning environment for students that incorporates field work and technological access to data with more traditional laboratory and classroom activities.
5. Foster and support the development of communities of science learners by establishing student teams; build networks of regional and national exchange through electronic means of communication; and utilize the services of other Earth and space organizations whose efforts relate to EarthComm.
6. Utilize local and regional issues to stimulate problem-solving activities and foster a sense of environmental and resource stewardship by students in their communities through the study of real-life problems and issues.
7. Take part in teacher and administrator enhancement opportunities that support the implementation of the above items through improved teaching methods.

EarthComm Goals and Expectations for Students

1. Improve scientific knowledge and understanding of Earth science concepts. Students should develop knowledge and understanding of practical and essential Earth science concepts and the principles Earth science shares with other disciplines.
2. Understand basic principles of Earth system science and think from an Earth system science perspective. Students should think from a systems perspective; they should understand that Earth is a complex, dynamic, evolving planetary system of geospheres, geochemical cycles, and energy resources that interact and influence one another; and they should understand that Earth is a subsystem of an evolving solar system, galaxy, and vast Universe.
3. Enhance scientific process and inquiry skills. Students should be able to describe, analyze, and evaluate objects and events both qualitatively and quantitatively; collect, display, and evaluate data; and synthesize reasonable inferences based on logical quantitative and qualitative methods of inquiry. They should be able to apply their scientific and technologic knowledge, understanding, and abilities to make wise personal decisions, increase their economic productivity, debate intelligently about issues of scientific and technological concern, and survive and succeed in society.
4. Develop technology-oriented abilities for human enterprises on Earth and in space. Students

should understand how technology increases our ability to understand the geologic history, beauty, complexity, and dynamic processes of change in the Earth system on time scales from less than a second to billions of years and in spatial dimensions from subatomic to the scale of the universe.

5. Understand the human dependency on energy, mineral, and water resources. Students should understand the nature, origin, and distribution of Earth's energy, mineral, and water resources; technologies used to locate, extract, and process these resources; and human dependency on these resources to satisfy their wants, needs, and expectations. They should understand numerical dating techniques and ways to directly and remotely map planetary surfaces.
6. Understand how natural processes and events are beneficial and hazardous to humans. Students should understand how terrestrial and extraterrestrial processes affect Earth's materials, environments, and organisms; how these processes are studied by scientists on Earth and from space, and how some processes benefit humans while others pose risks.
7. Understand how humans influence the Earth and develop a sense of Earth stewardship. Students should develop a sense of stewardship toward Earth through understanding that human activities influence Earth's spheres, processes, resources, and environments — factors that affect the size and distribution of human population and Earth's capacity to support life.
8. Develop a sense of career opportunities in the Earth sciences. Students should be aware of career opportunities in the Earth and space sciences, how professions and businesses benefit from technologies used by Earth and space scientists, and how these combined professions and businesses are related to regional economies.

EarthComm was drafted in 1998, pilot tested by 42 teachers in the spring of 1999, and revised by leading high school teachers (members of the National Earth Science Teachers Association) in the summer of 1999. The curriculum will be field tested in the 1999-2000 school year. Professional development workshops were offered for field test teachers at four universities in August of 1999. Electronic networks of field test teachers are being established at the regional and national levels to support the field test program. Further information about the project can be found on the EarthComm web site at http://www.agiweb.org/earthcomm/.

Geoprospects – Day of the Geosciences: An interinstitutional approach to bringing geosciences to the public eye

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In Germany, like in many other countries, it is a fact that the society as a whole does not have much awareness of the importance of the Earth Sciences in societal issues. Recent events like the disastrous earthquakes in Turkey or Taiwan, the landslides in the Italian Alps, the floodings in East Germany or most recently in Mexico help to enhance the awareness of our living planet, but the many links between the earth sciences and everyday life are still widely unknown. However, today human decisions concerning the future of our modern society require a reliable knowledge of the earth and its interconnected systems of geosphere, hydrosphere, atmosphere and biosphere. Issues of high societal significance are the sustainable development of the natural resources (water, fuels, minerals), the safe disposal of waste materials and the vulnerability of populated sites to natural disasters. Earth sciences with their profound understanding of the origin and dynamics of our planet Earth can enhance society´s ability to make wise decisions on these challenging aspects and hence contribute to a more equitable, prosperous and sustainable world.

More than two years ago the Senate Commission for Joint Research in Earth Sciences of the Deutsche Forschungsgemeinschaft (DFG) started to plan a complementary set of activities in order to bring geoscientific research and its relevance for our society to the public eye. The strategy focused on two parallel activities:

1. The preparation of a book demonstrating the relevance of geosciences for the society presented in a popular scientific way and
2. a symposium with a number of public lectures on geoscientific topics of general interest accompanied by an exhibition with conducted demonstrations and "hands-on" exhibits.

Both action lines were designed for communicating geoscientific themes and messages to the general public, especially school teachers, secondary level students, lobbyists and funding agencies.

The richly illustrated book "Focus Planet Earth" (Die Erde im Visier) - The geosciences on the threshold of the 21. Century" (edited by H.-P. Harjes and R. Walter and written by a well-known science-journalist) highlights in 20 chapters the breakthroughs in earth sciences research. Beside decision makers e.g. in funding agencies and ministries, an important target group of the book is teachers at the secondary level, aiming to enhance general appreciation for the solid-earth sciences and to improve the educational position of this discipline.

The "Geoprospects" symposium was organized under the auspices of the Deutsche Forschungsgemeinschaft and the UNESCO. The scientific topics of the symposium were derived from the challenges facing society, in which a fundamental understanding of the solid-earth sciences plays a primary role: 1. Five billion years of evolution – what message for us; 2. Mechanism of earth´s climate; 3. Natural hazards and its social impact, 4. Satellite based earth observation; 5. Natural resources and sustainable development; 6. Gas hydrates as a future energy resource and climate factor.

The symposium, held on the 30. September 1999 in Bonn, Germany, was accompanied by a week long exhibition (28. September – 3. October 1999). The idea behind the exhibition was to create a platform on which the visitor gets an "active and playing" access to the daily work of geoscientists and recent research achievements. Eight different stands, equipped with "please touch" and "living" exhibits like core-samples, drilling equipment, microscopes, video-clips, internet-connections, or on-line computer-information gave a close view behind the scenes of geoscientific research. Visitors could touch real gas-hydrates (stored in nitrogen), induce their own earthquake or talk via satellite-telephone with researchers at the overwintering station Georg-von-Neumeyer in Antarctica. All stands were manned by young scientists, able to explain the scientific and practicable background of the different exhibits. The evening of the 30. September 1999 a reception with representatives from public authorities, funding agencies and relevant science foundations took place.

About 1500 visitors from research, media, the educational, public and private sectors joined "Geoprospects" - Day of the Geosciences" to discuss the scientific challenges facing our society. "Geoprospects" seemed of particular interest to the highschool students. More than 40 schools visited the exhibition and the public lectures. To us, organizing "Geoprospects" was also a test of our ability to communicate with the youth, - important because they are the pool from which future scientists will come. "Geoprospects" can only be a starting point. It is one part in a puzzle of a growing number of activities, focusing on a closer dialogue with the public audience. Similar events must follow, to promote a greater public awareness of the earth sciences.

Outreach: Science in the Pub™

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Abstract

Science in the Pub™ is an initiative of the New South Wales branch of the Australian Science Communicators (ASC), a national association of over 400 journalists, editors, scientists, engineers, educators, and communicators committed to promoting a national awareness and understanding of science and technology.

A government grant of $3000 in 1998 was used to launch Science in the Pub™ (SciPub) for National Science Week and establish regular monthly sessions. A second grant of $6000 in 1999 supported a complementary initiative, Science in Your Pub so that SciPub sessions could be staged in centres around Australia for 1999 National Science Week and commissioning organisations. The grants were through the Science and Technology Awareness Program (STAP), Department of Industry, Science and Resources.

Science in the Pub™ is an outreach program which aims to bring scientific pursuits into the very heart of popular culture by having scientists meet members of the wider community in the informal setting of the pub—an icon of Australian culture.

The benefits of SciPub directly relate to the aims of the ASC (Table 1). The relaxed, informal atmosphere of the pub gives scientists the opportunity to hone their communication skills while promoting science as an exciting and enjoyable process. Debate, which focuses on scientific issues, is supported and directed through the informed opinion of the scientists. Although there is always a lot of fun over an ale or two, scientific integrity is never devalued.

ASC aims	SciPub outcomes
To foster professional communication of science and technology, especially through high standards in the crafts of journalism and other forms of communication	Presents professional scientists with the opportunity to hone their communication skills in an informal and relaxed ambience
To promote national awareness and understanding of science and technology	The promotion of small group awareness is the first step to a national awareness
To encourage discussion and debate on ethical, political, economic, and social issues related to science and technology	The major purpose of SciPub is to encourage debate on these aspects of science and technology
To provide opportunities for meetings between science	Each session brings together presenters who might

and technology communications professionals.	otherwise not meet or share ideas.

Table 1: In addressing the aims of the Australian Science Communicators, Science in the Pub™ works towards developing communication across a broad spectrum of the community.

Science in the Pub™ has had a remarkable run of success. The ABC radio records most sessions and five were broadcast on Radio National early in 1999. Six are to be broadcast over the next summer. Each session attracts an average of 80 people and most sessions feature celebrated scientists as panellists. Success has been attributed to:

1. the individual talents and professional experience of organising group members
2. the venue and its location
3. the carefully chosen panellists
4. the popularity of session topics
5. the wider community's enthusiasm for informed discussion and debate on scientific matters.

Organisation

Organising group SciPub is organised by a small group of enthusiastic volunteers, all members of the ASC. They take on tasks that relate to their particular skills and talents, such as:

1. producing and compering the sessions
2. identifying suitable issues
3. liaising with high-profile scientists with communication skills as presenters
4. helping with fundraising, such as raffles
5. general management and co-ordination
6. marketing, website, session evaluation.

Venue The 'home' pub for the regular monthly sessions is in Pyrmont close to Sydney's Central Business District. It was carefully chosen as representative of the true 'Aussie Pub'.
Some commissioned sessions have been staged in venues other than pubs. In these cases, the session is advertised as 'presented by the Science in the Pub™ team' in order to maintain the original image.

The panellists are usually chosen by the SciPub organising group which, through the diversity of members' backgrounds, has access to universities, CSIRO, CRCs, government departments and agencies, museums and other scientific research organisations. There is also substantial input from other members of the ASC. Panellists have included Sir Gustav Nossal; Pulitzer Prize-winning author, Laurie Garrett; Douglas Adams of *The Hitch Hiker's Guide to the Galaxy* fame, as well as a number of media identities.
In keeping with SciPub's informality, panellists are asked to present their abstracts in verse. These, in most cases, also add to the hilarity of the session. Eventually the SciPub 'pomes' are to be published as the *Science in the Pub Book of Bad Verse.*

Sessions 36 SciPub sessions have been organised since its inception in early 1998. Of these, 18 were the regular sessions held on the last Wednesday of the month in Sydney; 8 were organised for National Science Weeks 1998 and 1999, and 10 were commissioned as Science in Your Pub events presented in centres such as Brisbane, the Gold Coast, Melbourne, Canberra and NSW country centres.
The fields of science chosen for the sessions are usually those relating to popular issues identified as attracting community interest and debate. Environmental matters, conservation and astronomy feature most prominently in the program. However, regardless of the field of science, ethical, political, economic and social issues are always addressed and debated.
Of the 38 sessions only four have been directly related to geology or Earth science (Table 2). A number of others have included basic geological information.

Funding Apart from the government funding for National Science Week, SciPub has received no other support. Groups that commission sessions are asked to meet all expenses. There is currently a submission before government for support over three years to help establish SciPub as a commercial venture. With this in mind, Science in the Pub™ has been registered as a business and a trademark has been placed on its name. There are also submissions current for producing SciPub as a TV series.

Expenses for staging the regular monthly sessions are met through a small entry fee and a 'pub raffle'. The novel prizes for the raffle relate to the theme of the session and help to add to the fun. One of the prizes for the session, *'Gut feelings about Sydney water'* was a bottle of *'Sickie Water'*. The label suggested *'A dose of this Sydney water will guarantee sick days off within a fortnight of taking it.*

Evaluation Surveys have been collected from patrons for almost every session. These have been used to refine organisation and improve presentation. The surveys have also been used to determine audience profiles and learning from the session. These help with our understanding of the requirements of communicating science and the needs of the audience.

Promotion and marketing Very little effort has gone into promotion. Most of the patrons have learned about SciPub either by word-of-mouth, ASC membership notices or through internet listings and email addresses. The latter have been compiled from optional contact details given on the surveys and from direct contact.

The internet listings are extensive and probably reach more than 500 people. All email messages direct patrons to the SciPub website[1] which fully covers all details of both the program and organisation

Radio broadcasts of sessions and radio interviews of panellists have stimulated interest and resulted in additional names being added to email lists. Articles in the media have also increased awareness.
Survey results

Items on the evaluation forms cover personal details (age group, sex, level of science studied, postcode); responses to sessions (total number of sessions attended, source of publicity, enjoyment level, level of understanding, new learning, venue appeal, recommendation for new topics and presenters, general comments), and optional personal contact details.

Although there are variations from one session to another, an interesting outcome is the general changes that have occurred over SciPub's two years' of production.
For this article, evaluation results for two of the Earth science sessions. 'Rocks' and 'Energy' (Table 2) were compared with the general findings for each of 1998 and 1999. Only significant differences from the general trends have been reported on.

Age groups of patrons Consistently, the majority of patrons fall into the 26-35 age group. However, during 1999 there has been a significant increase in the 46+ age group and a fall in numbers of the 18-25 group. This is being investigated currently with initial indications showing that there is no relationship between the fall in numbers and the introduction of $5 entry fees.

Gender Although the number of female patrons has been slightly less than males over both years, the difference is probably insignificant: female range, 44-49%; male range, 51-56%. It was the 'Rocks' session that attracted the least number of females for all SciPub sessions (44% females: 56% males), while 'Energy' (48%: 52%) was within the average range.

Highest science learning This item caused despondency when the initial survey results were assessed in 1998. The majority of patrons were found to have postgraduate degrees in science, and this trend has continued into 1999. Together with the graduate population, these formed well over 70% of the total patrons. Does SciPub have an elitist following of high-flying scientists? Comments suggest that they enjoy the opportunity to learn about issues in science totally removed from their own discipline. Many also commented on the value of meeting scientists from other disciplines.

Consideration was then given to the 30% of non-scientists in the audience. Some of these had not studied science since junior secondary high school. Many have become 'regulars'. Their comments show that they consistently 'learn something new' each session and that they really enjoy the opportunity of speaking informally to distinguished scientists over a beer!

Of the Earth science sessions, the 'Rocks' session attracted over 80% graduates and postgraduates. However, this was not the case for the 'Energy' with only 65% graduates/postgraduates and a non-scientists group of around 35%.

Postcodes The demographic information from the postcode data is also disappointing. SciPub does not attract many from the local beer-drinking community. Only 1% have postcodes close to that of the pub. More than 50% live outside the 5km radius.

Regular patrons Sessions in 1998 averaged 50% of first-time patrons. By mid-1999, 19% had attended only one session over the two years. This suggests new patrons are attracted to topics specific to their own interests. There might also be an element of 'never again'. At the other extreme, there were a number who profess to have been to all 18 Sydney sessions. By mid-1999 most patrons had been to an average of four from the beginning of 1998.
The Earth science session, 'Rocks' was interesting in that 78% of the patrons were 'first-timers'. Is this another example of the characteristic 'preaching to the converted'? Did the audience comprise only graduate and postgraduate geologists uninterested in science outside their own? The evaluation did not extend to answering these questions.
New learning The responses to this item are very encouraging. Of a sample of 136, 73% stated that they had learnt something new from the session. Of these, 68% specified what they had learnt. This trend extended across all age groups and both sexes. However, there was a relative drop in new learner numbers amongst the postgraduates.

About 50% of 'Rocks' session patrons professed to have learnt about 'geodiversity' and the idea of geo-conservation for the first time. This opens a new line of enquiry.

Conclusion

SciPub is a highly successful program with potential as a tool for learning science in informal contexts (St

[1] http://newt.phys.unsw.edu.au/~mgb/SciPub/scipub.html

Lawrence 1992)[2]. As an outreach program it brings small groups of non-scientists together with professional scientists in the relaxed informal atmosphere of a 'pub'. It is also an arena for research scientists to communicate their work to the wider community at a suitable level of understanding.

Dr. Art's Guide To Planet Earth

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The Earth Systems Science approach has great potential to help the general public and pre-college teachers and students to understand how planet Earth works. Further, they can apply the conceptual framework of Earth Systems Science to understand the environmental issues that they hear, see and read about in the media. They can also apply these understandings to their daily actions.

Despite these potential advantages, the general public and pre-college teachers and students rarely encounter Earth Systems Science. Even at the college and university levels, there are many more traditional Earth Science and Environmental Science courses than there are Earth Systems Science courses.

Over the past five years, I have been presenting a show that introduces and illustrates three central principles that can help people understand how our planet works. These principles focus on Matter, Energy and Life in the Earth System. In brief, they introduce the conceptual framework that Earth is essentially a closed system for matter, an open system for energy and a networked system for life.

The show includes exciting scientific demonstrations and audience participation. It has been very well received by the general public and pre-college teachers and students. However, it can only introduce the concepts at a very simple level of understanding. To deepen the educational experience, I am writing a book and developing a web site that explain the concepts in greater depth and apply them to global and local environmental issues. By the time of the Conference, sample copies of the book will be available and the web site will be fully operational.

The next sections of this abstract provide more background on the three organizing principles and then discuss the rationale for using this conceptual approach and the plans for disseminating the show, book and web site.

Earth's Matter

Our planet has been circling the sun for more than four billion years. During those billions of years, the matter on our planet keeps changing its form. Water evaporates from the ocean, goes into the clouds and falls as snow and rain. Rocks get broken down into dirt that is washed as sediment into rivers. Plants take carbon dioxide gas from the atmosphere and convert it into solid sugars and starches. Why doesn't all the ocean water turn into mountain snow or all

[2] St Lawrence, Susan; Unexpected Learning in Adult Ed News, July, 1992.

the rocks turn into sediment or all the atmospheric carbon dioxide turn into sugar?

Earth still has oceans, mountains and atmospheric carbon dioxide because they are part of cycles - the water cycle, the rock cycle and the carbon cycle. Water flows in rivers back to the oceans; buried sediments reach the surface again through volcanoes; and animals chemically change sugars into carbon dioxide that goes back into the atmosphere.

Earth is a recycling planet. Essentially all the matter on Earth has been here since the planet was formed. We don't get new matter; old matter does not go away into outer space. The same matter keeps getting used over and over again. From a systems point of view, we say that Earth is a closed system with respect to matter.

Earth's Energy

Imagine what would happen if the sun stopped shining! This disastrous scenario emphasizes the role of solar energy in Earth's Operating System. Our planet relies on a constant input of energy from the sun. Earth receives an inflow of solar energy that is more than 15,000 times the amount of energy consumed by all human societies. This constant flow of solar energy into the planet provides virtually all the energy to keep our planet warm, drive the cycles of matter and sustain life.

If Earth retained all that energy, it would become so hot that it would just boil away. But energy does not like to stay in any one place. Energy flows away from Earth in the form of heat radiating to outer space. The amount of energy radiating to outer space exactly counterbalances the amount of energy flowing in from the sun.

Note the difference between Earth's matter and Earth's energy. With respect to matter, Earth is a closed system. Matter does not enter or leave. With respect to energy, Earth is an open system. Sunlight energy flows in and heat energy escapes.

Earth's Life

Earth's organisms form an intricate web of interconnections, with every organism depending on and significantly affecting many others. As one very important example, virtually all communities of organisms ultimately depend on plants. They capture energy from the sun and store it as chemical energy. Plants are Earth's producers.

With respect to food energy, the rest of the organisms are consumers. Some of us eat plants, others eat animals that eat plants and some eat both plants and animals. The plants, in turn, rely on animals for pollination or for spreading seeds and on decomposers for creating rich soil from dead waste.

With respect to life, Earth is a networked system. Not only do organisms form an interconnected web, they also participate actively in Earth's matter cycles and energy flows. Our existence depends on the web of life for the air that we breathe and the food that we eat. As our numbers have exponentially increased and our technologies have altered virtually every part of the globe, we have become a very important part of this web of life.

This Systems Approach

Any complex system, such as planet Earth, can be presented in a number of different ways. Earth Systems Science expositions generally introduce the parts of the Earth systems as the "spheres" – the geosphere, atmosphere, hydrosphere and biosphere. As described above, I prefer to introduce the Earth system in terms of matter, energy and life. Then the geosphere, hydrosphere, atmosphere can be easily introduced as the solid, liquid and gas parts of Earth's matter system.

Dr. Art's Guide To Planet Earth also provides a conceptual approach to systems thinking that is easy to understand and apply. Most introductions to systems thinking immediately jump into stocks, sinks, fluxes and feedback loops. I prefer to begin at a more general level that begins by asking why we care about systems, what are the characteristics of systems and how do we use systems thinking to help us understand complex phenomena.

I begin by describing how every interesting thing we encounter can be analyzed as a system which has parts that join together to create a whole that is qualitatively much more than the sum of its parts. Further, each of these parts can be described as a system in its own right. And the system we have been analyzing is itself a part of many larger systems.

The reason to care about "systems within systems within systems" is that it provides us with a way to understand any particular system, especially complicated ones like planet Earth. It does not matter whether the system is a person or your circulatory system or a car or planet Earth. No matter what the system is, we can always understand it better by asking three systems questions:

What are the parts of the system?
How does the system function as a whole?
How is the system itself part of larger systems?

Dr. Art's Guide To Planet Earth illustrates how these systems questions help us understand a very complex system – our planet. We explore Earth's matter system by analyzing Earth's solid, liquid and gas parts. In other words, we ask the first system question and as a result learn about the cycles of matter.

We explore life on Earth by investigating the relationships among our planet's organisms and how they interact with Earth's matter and energy systems. In the process, we learn about feedback loops and the web of life. In other words, we ask the second systems question and discover how a system as a whole can have unexpected properties that are different than those of its parts.

We explore energy in the Earth system and learn that the vast majority of the energy comes from the sun and then leaves in the form of heat. In the process, we learn about the flows of energy and how they influence life and Earth's climate. In other words, we ask the third systems question, looking at Earth as part of a larger system, the solar system.

Applying the Understanding

Merely knowing something, even something as important as how our planet works, is not enough. We need to apply that information in our lives. Dr. Art's Guide To Planet Earth applies this understanding of the whole Earth system to environmental issues that we face globally and locally. For example, the issue of global climate change arises from our disturbing Earth's matter cycles in ways that interfere with the flows of energy, specifically the way heat leaves the Earth system. Further, the resulting changes in climate can have drastic effects on the web of life, especially in combination with other human actions that destroy and alter habitats.

The book and web site analyze a wide variety of global and local environmental issues using a systems approach and the conceptual framework of the three principles. Systems thinking teaches that we cannot predict the changes that will occur because of all the different ways that we are impacting Earth's systems. The logical conclusion is that we should generally act to preserve the pre-industrial cycles of matter, flows of energy and web of life.

A Presentation System

I began using this approach in my show and then expanded it as I provided professional development for high school teachers. The show has a very useful function in introducing the ideas in an educational and very enjoyable format. I am currently developing ways to teach others to do the show and provide them with resources that will assist them.

Any one-hour show has obvious limitations in the depth of the materials that can be presented. I have therefore written a book in order to enable the general public and pre-college teachers and students to understand these concepts in greater depth and apply them in their lives.

In my experience, books written by scientists tend to alienate most people because of their conceptual level and their format. I have therefore made great efforts to avoid excessively technical language and concepts. My guiding question is - what do we people really need to know to understand how our planet works? Further, I am collaborating with artists in their late-20's to design and illustrate both the book and the web site. I believe this collaboration is providing a visually attractive format.

I also believe that it is essential to include an on-line and interactive version of Dr. Art's Guide To Planet Earth. The web site (planetguide.net) aims to provide experiences and resources that complement the book and the show. In addition, it provides an inexpensive way to introduce and advertise them.

The web site does not attempt to replicate the book. Instead it has features that cannot be provided by books. For example, it includes animations and simulations that help people interact with the concepts. People can input different rates of carbon dioxide emissions and examine the resulting changes in atmospheric composition.

The web site also provides opportunities for questions, answers and discussions. It can include experiments to do at home or in schools as well as links to related resources. The web site can include a calendar of show presentations. Unlike a book, all these features can be updated quickly.

In conclusion, Dr. Art's Guide To Planet Earth provides a systems science approach to understanding how our planet works and applies that approach to global and local environmental issues. It features an integrated presentation system that includes a show, a book and a web site.

Geodiversity Centre, Australian Museum: Its Role in Geoscience Education

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The Geodiversity Research Centre within the Australian Museum promotes research into the geological sciences. The centre supports projects that advance earth science research but also aims to broaden the Museum's research links and promote geoscience education through various avenues. The centre has operated since 1995.

Geodiversity embraces two concepts. One is the straight forward diversity of geological processes that contribute to the evolution and environment of Earth. The other, a more holistic concept, considers geodiversity in terms of human endeavours which include geo-heritage, geo-conservation and geo-education. Geodiversity is promoted as a basic environmental subject of educational value.

The Geodiversity Research Centre considers projects within fields such as:

G - **Geobasics** (earth processes)
E - **Environment** (pollution, hazards)
O - **Origins of Earth** (planetology)
D - **Deep time** (geochronology)
I - **Impacts from space** (meteoritics)
V - **Volcanism** (volcanic effects)
E - **Evolution of Earth** (palaeontology)
R - **Rocks** (primary and secondary)
S - **Seisms** (earthquakes, tsunamis)
I - **Industry** (ores, gems, building stones)
T - **Tectonics** (plates and structures)
Y - **Yearning minds** (geo-education)

It is important to feed new research results from these projects into a range of geo-educational resources. This freshens up geo-educational programs, enlivening interest and enthusiasm for the subject. These 'mind grabs' can be presented in many forums, including:

- Museum public programs
- Museum Society events
- Popular publications
- Students' books
- Lecture circuits
- Field forays
- Workshops
- School kits
- Media

An example is drawn from a geodiversity research project on pumice found in an Aboriginal midden at Balmoral Beach, Sydney. Research results showed this pumice washed up from eruptions in the Tongan Islands, 1800-3300 years ago. These results contain much educational 'milk' as they draw together concepts of volcanism, ocean currents, biological transport, coastal processes and Australian archaeology. It is planned to expand this project to cover a large section of east Australian coastlines and involve 'Coast Watch' programs for future pumice arrivals. In this way the research project takes on an active role in public education and participation.

In its present activities the Geodiversity Research Centre is producing two books of educational scope. One is a guide to the gemstones and minerals of Australia for distribution by an Australian publisher. This will provide an educational reference source for fossickers, collectors and teachers. The other is a children's book on earthquakes and volcanoes for the 8-13 years age group. This book will provide an updated worldwide source of information on these topics and provide a reference source for primary school teachers.

Earth Science Education in New Zealand Schools
- changing the emphasis

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Over the last 15 years, the New Zealand Geological Society, primarily through it's Geological Education Group, has successfully lobbied for increased earth science content in the New Zealand school curriculum. At the same time, as the effects of free-market economic policies of successive New Zealand Governments hit closer and closer to home, geologists witnessed a dismantling of the DSIR and the downsizing of many other science providers, resulting in significant numbers of co-workers and colleagues losing jobs or, eventually leaving the profession for a less stressful existence elsewhere. Examination of Editorial comments and 'Letters to the editor' in the newsletter of the Society have and continue to push the concept that the geological fraternity must become more actively involved in earth science education in schools in an attempt to bring what has been a progressive decline, to a halt.

'This involvement (with schools, KMS) will have little short-term benefit, and given the time it takes away from research publications may even be detrimental to one's career. But our involvement is necessary to our long-term prosperity and survival.'

'The new science curriculum goes a long way to educating our future taxpayers.'
NZ Geol. Soc. Newsletter #105, 1994

In many respects, for a portion of the membership of the Society, the introduction of the 'PLANET EARTH AND BEYOND' strand into the New Zealand school science curriculum in 1994, was cause to celebrate, the rest was up to the teachers. Additionally, despite the fact that repeatedly in Newsletters, the membership is made aware of the fact that few teachers have any formal training in earth science, the Society and individual members continue to produce and advertise 'resources' for schools which, because of content and jargon, will rarely be used in the classroom. A geological map presents an enormous amount of information, much of it abstract, to a privileged few who have learnt how to read and interpret same; field trips guides, most again produced for the professional attending a conference, also have little value for the same reason. As a community, geologists in New Zealand undertook to bring radical change to the New Zealand Science Curriculum, once that was achieved, that community then failed to deliver what was required to maintain the momentum.

'Acceptance of more earth science teaching at secondary school level will of necessity, demand greater availability of teaching resources. Ultimately this is the responsibility of the Department of Education.'
NZ Geol. Soc. Newsletter #71, 1986

Ironically, the key as to how such resources could evolve with significant spin-offs for the geological community, was indicated in a document 'Science in the New Zealand Curriculum' published in September, 1993 and referred to in Society newsletter #102 of the same year.....'geology is a wonderful vehicle for teaching science' and later, 'An integrated, thematic approach over several subject areas is particularly appropriate for aspects of this achievement aim.'

During 1997-8, the Department of Geological Sciences at the University of Canterbury produced and distributed a set of 9 posters to intermediate and high schools throughout New Zealand. The themes covered by the 'Geology is....' series covered a wide range of topics and were selected to introduce geological subject matter, which in this writer's view, had potential to be developed for use in the classroom. The second part of this outreach programme was to develop one teaching module for each poster. The first, titled 'Portrait of a Goldrush' was completed in June, 1999 and distributed to schools throughout New Zealand. The first draft of a second module, 'Microfossils - small is great', has been distributed for assessment, to science teachers attending a field-oriented, geology workshop, held at Canterbury University in November last year. In many respects, these modules were designed as 'primers', a resource which helps a teacher to see what is possible. In the 'Goldrush' example, aspects of human history, economic geology, elementary statistics, chemistry, mineralogy and physics are presented in such a way that a) the teachers are able to target subjects for emphasis and b), the interrelationship between geology and other sciences is subtly expressed. A simple laboratory kit, comprising a shallow aluminium tray and small sample of Tauranga Bay blacksand, allows the student to replicate some of the fascinating patterns created by wave action on the beach. Classroom discussions as to why such patterns develop illustrating the multidisciplinary nature of geology as a science.

'......an integrated, thematic approach over several subject areas.'

Providing resources for the new HSC subject Earth and Environmental Science - a university perspective.

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Introduction

In November 1997 participants at a two day symposium organised by the New South Wales Board of Studies recommended that, because of dwindling enrolments, the existing Higher School Certificate subject in Geology should be replaced by a new subject entitled Earth and Environmental Science. An 18 month period of discussion, design and debate then ensued and the new syllabus was formally released in July of 1999 for introduction in 2000. The new syllabus is radically different from any subject that has preceeded it and teachers therefore face a formidable challenge in designing teaching programs for it and acquiring resources that will enable them to teach it in an appropriate fashion. Many teachers who will be involved in teaching the new subject have no experience, or qualifications, in either/or Earth or Environmental Science. Staff at the University of New South Wales (UNSW) have been involved in the development of the new syllabus from the very start and strongly believe that the new subject can play a major part in reviving interest in both Earth Science in particular and Science in general. The University was therefore prepared to assist teachers by whatever means were required.

Searching for a mechanism to provide assistance

The two Schools of Geology and Geography at UNSW have the personnel with the sufficiently broad range of skills and expertise required to cover all topics mentioned in the syllabus. An initial meeting of interested staff in July 1999 decided that we should do whatever was required to assist the secondary science teachers involved. We decided that an initiative at several levels was required. This could be summarised as follows:

- The provision of teaching program summaries.
- Provision of a listing of categorised Web sites.
- The organisation of a Workshop primarily designed to provide guidance to teachers.
- Opportunity within the Workshop to assess the true resource needs of the teachers.

The workshop ran between the 2nd. and 4th. of December, 1999. It consisted of two days spent on campus at UNSW and a day spent in the field. Extensive discussion of teachers needs occurred at the Workshop and further information was obtained through the use of a post-workshop questionnaire.

The workshop and its outcomes

65 teachers attended the Workshop. Of 15 presenters, a third were drawn from the secondary education sector and were either teachers or were responsible for the training of teachers and the rest were university staff. Presentations covered the technical content of all modules comprising the Preliminary (Year 11) part of the syllabus, techniques for the efficient use of the Web, methods for attracting students to the new subject, methods for teaching within the history and philosophy of science context of the new subject and strategies for making the fieldwork component both worthwhile and exciting. Lengthy discussion periods were scheduled within each presentation session.

Most presentations were delivered using well-illustrated PowerPoint presentations using a common template and this served to ensure a largely uniform standard of presentation and readability in both the presentations and associated written notes.

Using a 5 tier scoring system the Workshop was assessed by participants to be at the top level, excellent, on almost all counts. All materials provided were rated as excellent but the occasional presenter was identified as needing to improve their presentation skills. The text references, reprints, Web sites and teaching advice was rated as excellent although the workshop presenters recognised that their efforts were only a first step. Approximately two thirds of participants attended the one day workshop on generic field skills and this was similarly well received.

The end-of-Workshop questionnaire was completed by most participants and has facilitated a detailed analysis of further teacher needs.

Further teacher needs

Participants at the Workshop have made it clear that they will attend a second workshop, planned for 2000, to cover the HSC (Year 12) parts of the syllabus. They have also indicated, in order of priority, that they need:

1. An Australian Earth and Environmental Science textbook.
2. Rock specimens with descriptions
3. An environmental change case-history with imagery.
4. Ideas for the "open-ended investigations".

Implicit in responses to other parts of the questionnaire is a need to also maintain the Web links listings already provided.

The questionnaire also served to identify a requirement for tertiary institutions in NSW to provide postgraduate training in the various disciplines involved in Earth and Environmental Science. UNSW will respond to this need by the provision of Certificate and Diploma courses that will be delivered in non-conventional format.

"Down-side" considerations

Tertiary academics in Australia have suffered increasing work-loads and reduced assistance and resources in recent years. The promotional system still places the greatest emphasis on the academic's level of research as demonstrated by the number of peer-reviewed papers. Many academics recognise that only lip-service is given by the promotions committees to contributions to the wider community or the profession. For these reasons, not all academics within the two Schools were prepared to make contributions to the Workshop or alternatively did not place their contribution at the highest possible level of priority. This was despite a widespread recognition that the Workshop would play a significant role in raising the profile of UNSW and would, in the long run, be beneficial in attracting more students to the sponsoring Schools. It is suggested here that participation in extensional activities designed to enhance the links between the tertiary and secondary sector be recognised as a necessary part of every academic's work load and that appropriate note of such service be taken by promotion committees at all levels. If such a move is not made then those who put in the effort this time will be less likely to make the personal sacrifice again and the University as a whole will be the loser.

Having now begun a program of resource provision to the secondary teachers, including such things as the Web links listings, it is necessary to maintain this effort to ensure that the university obtains appropriate benefit from its efforts. There will be an on-going cost involved in maintaining these activities.

"Up-side" considerations

The secondary school community now recognises the Schools of Geography and Geology at UNSW as having considerable expertise in Earth and Environmental Science. The teachers concerned play an important role in advising their students about suitable tertiary programs. The likely downstream benefit to UNSW is clear. A network between the teachers and the UNSW Schools now exists that can be built upon for further, similar, exercises. The Workshop has allowed the University to identify a new opportunity for the provision of postgraduate training that had not previously been fully recognised.

The workshop required all contributors to make their presentations from a holistic, Earth Systems, approach. This allowed the academics concerned to identify potential synergies and opportunities for future collaboration that had not previously been recognised. The Workshop has therefore had a direct benefit to UNSW in enhancing the relationships between the academics concerned.

Conclusions

The initiative by the University to provide assistance to secondary teachers involved in delivery of the new Earth and Environmental Science subject has been of direct benefit to both the recipients and the University. It is believed that these benefits will be on-going and that such activities will therefore become an important part of every tertiary academics work load.

Educational Opportunities in a Cooperative Research Centre

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Introduction

The Australian Government instituted a system of Cooperative Research Centres (CRC) in July 1995 with the objectives of bringing together the nation's universities, research organisations and industry to achieve improved working relationships between them for the benefit of the country. One important outcome of the initiative was to ensure the future through devotion of significant resources to educational pursuits. Because of the link between research and industry many of the CRC's are working at the forefront of commercially viable research and such areas are often outside the normal range of undergraduate training. Postgraduates are often involved in such research as part of their training. Some 65 CRC's are operating in Australia today, although the number in Earth science is only about five.

In 1995 the Cooperative Research Centre for Landscape Evolution and Mineral Exploration (CRC LEME) was formed as an unincorporated joint venture between the University of Canberra, the Australian National University, CSIRO and the Australian Geological Survey Organisation. Its objectives are to:

1. establish a framework for greater understanding of the three-dimensional evolution of the Australian landscape;
2. translate this knowledge into a greatly improved ability to recognise major mineral deposits;
3. integrate industry-supported research with education to ensure a skills base for industry, general Earth-science communities and for further research; and,
4. inform and guide decision makers of the relevance of this field of research to Australia's future.

Regolith geology and geology in Australian universities

If you look at an outcrop geological map of Australia it is about 50% covered by Tertiary and/or Quaternary 'cover'. Of the rocks that are shown to crop out, most are significantly weathered, many deeply. University courses in this country generally do not provide any systematic coverage of these regolithic materials. Most graduates do not have the tools to describe, map or interpret regolith materials. The nature of regolith is often related to landscape evolution and this is a subject that gets even less attention in geology courses in this country. By far the greater majority of Australia's Earth science graduates are regolithically and landscape illiterate, despite the continent being dominated by regolith and the most visible part of our continent, like any others, is the landscape.

The reasons for this ignorance of the upper-most layer of the continent are outlined elsewhere (Taylor 1998). It is none the less surprising that this should be the case. It is on the regolith and landscape we depend for our lives, our environment, the majority of our resources and our ecology, yet we persist in not teaching much of it in our geology courses. This was not the case once. At the turn of the century geologists were taught a lot of these things, but specialisation and selfishness has led to their not now being taught. Over the last 10 years or so the mineral exploration industry has realised that knowledge of the regolith and chemical activity in it are essential if we are to explore successfully for new ore deposits. This interest and the growing interest in environmental geology have led to a resurgence of interest in regolith and landscapes. The advent of CRC LEME added credibility to the discipline of regolith geology and funds to develop it.

Additionally Earth science has become a discipline not popular with first-year university students as they generally have little or no exposure to the subject prior to beginning their tertiary education. Australian schools do not teach geology as a separate subject up to year 10 and very few teach it at all in years 11 and 12. The majority of geology majors at university come from those few who do take geology in their first-year and get turned on to it as a subject.

At universities geology courses have such small numbers that gradually departments are being either eliminated or merged with other natural resource departments. Consequently the number of students and departments are decreasing so the courses that remain are looking for niches that ensure they are unique in order that they give their continued existence some assurance.

The presence of a CRC LEME in our department, one that happens to be merged with ecology, water science, and environmental science, has made a vast difference to the continued viability and vitality of geology in the university.

CRC LEME contributions to geology teaching at the University of Canberra

Staffing

Through CRC LEME we have appointed one fill time equivalent lecturing staff who also undertake research for the CRC. Additionally we have three post doctoral fellows, based at other research facilities, and a large increase in research student numbers who provide a valuable tutoring resource to undergraduate students. This increase in people in the department has lead to increased:

1. teaching resources;
2. research activity;
3. departmental vitality;
4. increased number of seminars and workshops;
5. team feeling; and,
6. social activity,

all of which lead to a much improved working environment and dramatically more intense research culture in the department.

Since some of the staff appointed by CRC LEME are younger than those who have been longer in the department undergraduate students are experiencing a new enthusiasm for the subject. A consequence of this is that increased numbers are taking first year geology as an option and more of them are opting to continue with geology as a major.

Belonging to CRC LEME also enables us to call on the expertise of more than 50 research staff at other organisations that are part of CRC LEME, to teaching in our programs. This exposes undergraduates to lectures and field trips to researchers working at the cutting edge of regolith science, an experience we could not afford without the CRC. This additionally gives our department us ready access to experts in fields of geology we could otherwise not afford to employ. For research students it provides a wider range of advisors who all have access to CRC LEME scientists to assist them in progressing their projects.

Research student opportunities

Research students are an important part of any department. They keep the place vital and a challenging place to work. Their research also forms the 'pistons of the research engine' in most departments, no less so in ours. In these times of low resource prices, rationalisation in major minerals exploration companies and a government policy that sees resource-based industries as sunset enterprises, it is difficult to fund student research projects. CRC LEME with its industry oriented research and substantial industry and government funding allows us to fund student's projects as part of larger research programs being undertaken in CRC LEME.

Working as part of larger research teams provides students with networks, facilities and experience that would not otherwise be available to them in a normal departmental situation.

Fieldwork, which forms the backbone on most geological and particularly regolith geology research, is well funded. Additionally the contributions from LEME have meant we can train and equip our research students in a safe way for working in remote localities, something the neither the department or the university provides despite OHS rules that specify they should.

CRC LEME maintains eight postgraduate and six Honours years scholarships that allows us to ensure fair-sized cohort of research students is in the department. Students also study on Australian Postgraduate Awards that CRC LEME tops up to about $20,000 per annum so ensuring we maintain high quality students in the Centre and its constituent departments.

Undergraduate students opportunities

CRC LEME offers three undergraduate scholarships per year at the University of Canberra. These comprise $1000 stipend plus attendance at a regolith conference and a mentoring program. The scholarship raises the profile of regolith geology in student's minds and provides incentive for them to proceed in its study.

Undergraduates in their senior years are also eligible for research applications scholarships of three months with a payment of $3,000. This enables students to experience professional work in the minerals exploration and research fields. Over the last three years twenty students have been placed under this scheme.
CRC LEME also annually runs a National Undergraduate Regolith Geology School (NURGS) that offers one student from all Australian universities the opportunity to attend a week-long school at a significant mineral exploration locality. The School consists of a week of lectures, tutorials and field work. It is run by CRC LEME to overcome the lack of regolith training in the majority of Australian university departments. To date two have been held, one at Charters Towers in far-north Queensland and the other at Broken Hill in far-western New South Wales.

These Schools have been a great success in teaching students of the importance of regolith geology and has led to some continuing to complete an Honours year in the subject.

Research and teaching facilities

CRC LEME being a joint venture between UC, ANU, AGSO and CSIRO brings together a collection of research and teaching facilities unequalled in Australia. Members of the CRC including students have ready access to a wider range of investigative technologies that is possible to achieve without such an arrangement.

Students and staff have ready access to two XRD's, XRF's, ICPMS's, several SEM's, a TEM, SHRIMP, an electron microprobe, palaeomagnetic laboratories, very advanced computer-based mapping and GIS systems, an AAS laboratory as well as many other minor equipment.

As well as the equipment students and staff also have access to training and advice on using the equipment and the interpretation of results.

The future

CRC LEME is beginning a project to develop CD-based interactive teaching modules. The first will be on regolith geology and minerals exploration. We are soon to publish a textbook on regolith geology. Other educationally oriented initiatives include:

Conclusion

The existence of a CRC in a department leads to:

1. increased staffing;
2. improved opportunities for scholarships;
3. increased team-work;
4. improved team feeling as a result of a common focus for teaching and research;
5. improved prospects of the department's longevity;
6. better opportunities for undergraduate students to learn; and
7. a sense of relevance to the department's work.

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Geothermal Geology Teaching at Gadjah Mada University: An Example of Integrated Geoscience Teaching for Undergraduate Students

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Introduction

Education has a very important role in producing qualified human resources in the fields of geothermal exploration and production, and to increase their quantity, which currently are relatively small compared to the geothermal potential of Indonesia.

A Geothermal project usually requires a multidisciplinary team where each member should not only mastering his/her own knowledge but is also able to communicate it to all the team members. In addition, each member of a geothermal team should be ready for working in a multicultural environment.

Geological Engineering Department of Gadjah Mada University (GED) has been participating in supporting geothermal education and research development in Indonesia. In geothermal education for undergraduate level the Department has been developing a syllabus for Geothermal Geology since 1987. Geothermal geology is a compulsory subject for stage-3 undergraduate students taking Geology of Energy Resources stream[3]. This subject requires knowledge of general geology, petrology and mineralogy, structural geology, stratigraphy, volcanology, and geohydrology. The students should also have taken geochemistry and exploration geophysics subjects.

The aim of the lecture is to provide a strong background knowledge on geological aspects of geothermal energy, and to generate an appreciation for interrelationship between the various disciplines necessary in geothermal projects.

Teaching Materials

Since the establishment of Geothermal Geology subject in the undergraduate program at GED the

[1]There are 4 streams of study offered at GED: Environmental Geology, Geology of Energy Resources, Geology of Mineral Resources, and Geodynamics

teaching materials have been upgraded. The core of the current lecture consists of the following topics:

1. Introduction to geothermal energy
2. The geological occurrence of geothermal systems
3. The role of geology in geothermal resource development
4. Thermal, hydrological & chemical structures of geothermal systems
5. Surface manifestations of hydrothermal activities
6. Geological mapping in a geothermal area
7. Permeability in a geothermal system
8. Magmatic heat source
9. Hydrothermal alteration
10. Logging a geothermal well
11. Introduction to geothermal geochemistry
12. Geological background for geophysical surveys in geothermal areas
13. Introduction to geothermal reservoir engineering
14. Integrated geoscientific approach for geothermal studies

These topics are partly taken and modified from the Diploma in Geothermal Energy Technology teaching at the Geothermal Institute, The University of Auckland (see Browne, 1995 a & b, Hochstein & Soengkono, 1995, Freeston & Dunstal, 1995), with more examples of applications for the Indonesian fields.

Some slide show series are utilised as teaching aid media for topics which need visualization, such as introduction to geothermal energy, surface hydrothermal manifestations, hydrothermal alteration, and the integrated geoscientific approach.

Field Trips

A field trip to a producing geothermal field is arranged to give the opportunity for the students to see the real geoscientific and the technological aspects of a producing geothermal field. This also allows the students to have a fruitful discussion with the staff of the operating company.

A one-day field trip to Dieng geothermal field (a water-dominated geothermal field closest to Yogyakarta) is usually conducted near the end of the lecture. Additional trips to Kamojang and Darajat geothermal fields (West Java) were sometimes conducted in the past on the students' initiative, and were organised by the students.

Teaching Methods

The duration of the lectures is 16 weeks, with 2 hours meeting per week. The students are expected to attend all the lectures in the class/laboratory, and to study the subject independently *at least* 2 hours per week.

The teaching in such a large class (70 students/year in average) is conducted by two-way communication. The students are strongly encouraged to participate actively in the teaching and learning process. At the beginning of the lecture there is a review on the previous one, and discussion on the students' findings during their independent study.

Some in-class lectures are followed by visits to the laboratories of the Geothermal Research Center. For the laboratory visit purpose the class are divided into 4 - 5 groups.

There are two types of assignment for the students, i.e., (1) assignments on data processing and interpretation, and (2) assignments on the literature review. The type (1) assignments aim to familiarise the students with real geothermal geological work. The type (2) assignments are set to encourage them to keep up with the up-to-date geothermal researches.

Overcoming The English Language Problems

Like other fields, geothermal science and technology develops rapidly, and so do the publications on them. Most of the information on them are written in English. Besides, those who wish to pursue their careers in geothermal companies & research institutions are required to have excellent English reading and writing skills. This skill is also undoubtedly important to help survive in a multicultural work environment, such as that in geothermal projects.

English Language is usually introduced to the Indonesians students at the Junior High Schools, although some students have begun studying English earlier. English Language is a compulsory subject for the stage-1 undergraduate students at GED. However, since it is not spoken daily, many students find it is difficult to keep up with English information. The students at GED are responsible to overcome this English Language problem by setting up an English Conversation Club (organised by the GED Students Union).

The official language in teaching is Bahasa Indonesia, but the lecturers can help the students to familiarize them with English information. The following ways have been applied at the Geothermal Geology class:

1. Showing the main points of the lectures (on screen) in English, explain them and continue the lecture in Bahasa Indonesia
2. Use both English and the equivalent Indonesian words for common geothermal terms.
3. Set some assignments on literature review.

In-Course Evaluation

The Geothermal Geology is a large class with approximately 70 students. We expect that at the end of the lecture the students have a "big picture" of geothermal geology with some proportional and adequate background knowledge on geothermal geochemistry, geophysics, and reservoir engineering.

The in-course evaluation aims to assess the students' achievement and the success of the teaching method.
So far the evaluations are done by:
1. Analysing the students achievements through the assignments, tests and exams.
2. Analysing the students' feedback on the teaching method and materials.

Supporting Conditions

The Geothermal Geology teaching at GED is supported by the following conditions:
(1) The curriculum for the undergraduate program at GED which provides subjects required as strong bases for geothermal geology
(2) The existence of the Geothermal Research Center at Gadjah Mada University, which allows:
a) laboratory visits for geothermal teaching
b) library utilisation
c) students involvement in geothermal researches
(3) The strong cooperation between GED and geothermal institutions and geothermal professional organisations which allows:
a) information exchange
b) training & study continuation for teaching staffs

Future Plans

It is planned for the near future to invite the participation from the geothermal industries, and research agencies outside Gadjah Mada University in increasing the quality of the geothermal education in GED. The forms of their participation can be:

1. Guest Lecturing

Guest lecturing by geothermal experts from outside Gadjah Mada University can give the students some first hand information about geothermal works.

2. Integrated Evaluation

The geothermal science and technology are developing rapidly, and so do the trends of geothermal projects. In order to maintain the relevancy between the university products and the demand of the users (geothermal industries and research agencies), the syllabus, the teaching materials and methods therefore, need to be continuously evaluated in an integrated manner. It is planned, for the near future to invite the participation of the users in this evaluation.

Concluding Remarks

The integrated geoscientific teaching can help generate the students' appreciation for the interrelationship between various disciplines required in a project. It is expected that, by beginning with this appreciation they can be cooperative geologists in geothermal teamwork in the future. This type of teaching, which should be applied for teaching the advanced-level subjects, will also inspire students to solve problems by using integrated interdisciplinary approach.

The institutions outside the university, i.e., the industries, research agencies, and professional organisations can play important roles in increasing the quality of geothermal teaching by providing the up-to-date scientific information, participating in teaching as well as in evaluating of the syllabus and the teaching materials.

Additional Notes

The stage-4 students passing the Geothermal Geology subject can do their Final Task (equivalent with B.Sc. thesis) on selected geothermal topics. Those interested to do some practical jobs on geothermal projects are directed by the GED to do their Final Tasks in geothermal companies. Those interested to do research are encouraged to participate in some research programs run by the Geothermal Research Center Gadjah Mada University or other geothermal research agencies outside the university.

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Integrating Geo-Science into Waste Management

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Abstract.
Global concerns for environmental and waste management issues present an opportunity and a challenge to mobilize geo-science resources and capabilities for developing solutions. The world is producing an increasing amount of waste with decreasing disposal space. Geo-science should be integrated into environmental and waste management instruction, research and outreach programs of universities. Universities train environmental and waste management professionals who assume leadership roles in industry, government and academia.
The approach to environmental and waste management education should rest upon a solid foundation of geo-sciences, applied and social sciences, engineering, technology and law/policy.

Waste management concepts are infused into the following geo-science courses at North Carolina A&T State University: biology, chemistry, hydrology and water resources, natural resource conservation, energy systems, physical geology, geography, bio-systems, environmental Science, earth system science, wetland management, and soil science.

North Carolina A&T State University took advantage of its geo-science programs which is housed in the Department of Natural Resources and developed an interdisciplinary Waste Management Institute (WMI). The Institute was developed to help raise public consciousness of environmental and waste management issues and to prepare graduates for careers in waste management fields. The objectives of the WMI are as follows: to increase the number of professionals who will work in environmental and waste management fields; develop cooperative and exchange programs involving faculty, students, government, and industry; serve as institutional sponsor of public awareness events, conferences, workshops, and lecture series and support interdisciplinary research programs

The WMI at North Carolina A&T State University has an unique certificate program in Waste Management. A Waste Management Certificate is awarded to undergraduate students who have completed a minimum of 18 credit hours of recommended environmental and waste management core courses. The Certificate in Waste Management complements the studentπs B.A./B.S. degree. The following are selected examples of waste management certificate courses: soil environmental chemistry, environmental soil microbiology, environmental soil physics, air quality, hazardous materials handling, pollution control, solid waste management, nuclear physics, environmental remediation, environmental engineering. modeling of contaminant flow, occupational safety and health, industrial hygiene, water quality modeling, water and waste water, environmental toxicology, environmental education, environmental economics, environmental biology, radiochemistry, soil genesis and land-use, industrial ecology, environmental history, environmental politics, and environmental problems/independent study (all disciplines).

The Institute is addressing the following research areas: Extraction of Pollutants from Soil with Organic Surfactants, Low-Profile Stripping of Organic Pollutants, Low Level MixedManagement, Estimation Scheme for Subsurface Contaminant Model, Mycological Potential for Trichloroethylene Remediation, Modeling the Effects of Thermal in Situ Technologies on the Dynamics of Subsurface Microorganisms, User-Centered Database System for Assessment and Evaluation of Environmental Restoration Technologies, Development of a Relational Database for Remediation Technologies, Hydrotreatment of Sulfur-Containing Organics Using High Surface Area Molybdnum, etc.

The Institute coordinates the following outreach programs: Precollege Environmental
Technology and Waste Management Workshop for public school students and teachers in grades K-12 and Earth and Environmental Science Summer Institute for teachers.

Aspects of Earth Science Education
Tertiary – High School Links in New Zealand

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Introduction
Research undertaken as part of a longitudinal study into aspects of Earth Science education in New Zealand secondary schools and first year university Geology students is presented. Data from 1997 and 1998 were obtained from the University of Canterbury only. In future, data from other Universities will be included so as to provide a national 'snap shot' picture of students at first year level. Secondary schools surveyed were from the Canterbury province centred in Christchurch, New Zealand.

The study aimed to determine the impact of the recently introduced secondary school Science curriculum (1994) on first year Geology student knowledge of Earth Science topics and to investigate secondary school **Science** teachers' backgrounds and attitudes towards teaching the Science curriculum. First year university students are typically 18 years old and are operating at what is called curriculum level four in the new National Certificate of Educational Achievement or NCEA.

A survey of school Earth Science resources, curriculum delivery and perceived resource needs was also carried out. The New Zealand Science curriculum now requires that equal teaching time be spent on teaching the strands of Physics, Chemistry, Biology and **Planet Earth and Beyond**. Teaching time for each strand per year at curriculum level 6 or year 11 (NCEA level 1 or 15 year olds) is approximately 26 hours.

Evidence shows that few schools have managed to provide and implement this amount of time. Unlike Physics, Chemistry and Biology, Earth Science *per se* does not branch out into a separate Science at years 12 and 13. At present, the only way a student can study Earth Science and Astronomy at senior High School level (years 12 and 13), is for a school to offer the national Science curriculum or prepare a specific non advancing course. To my knowledge, no secondary school in New Zealand offers a year 13 course in Earth Science and only a small percentage (12%) of the surveyed schools offered years 12 and 13 Science. Only one school out of the seventeen surveyed offered year 12 Science only. However, 44% of schools said that they would *like to offer* year 12 and 13 Science with 6% being unsure for a variety of reasons such as fear of subject competition, compromising standards and potential harm to staffing of the already established Sciences!

Initial data was gathered from a project carried out during tenure as a recipient of a Royal Society (NZ) Science and Technology Teaching Fellowship in 1997. These Fellowships enable teachers of Science and Math's to apply for what is effectively sabbatical and professional development leave from the classroom. Programs vary from marine science studies, bioethics, Antarctic research, museum studies and even winemaking. Salaries are paid as normal but relief teacher costs to the school are paid for by the Fellowship scheme. Each recipient is hosted by an organisation willing to provide appropriate resources and become involved in the recipient's programme of work and research.

My Fellowship was generously hosted by the University of Canterbury's Department of Geological Sciences where I became involved in investigating aspects of geological education at secondary school and first year Geology courses. School resources in Earth Science continue to be developed as a result of this project. An associated research project involved a comparative palaeoecological study of early Pleistocene subaqueous marine debris flows. This research has since continued with studies of the microfossil palaeoecology of a Pliocene siltstone formation.

The Survey Questionnaire
Questionnaire design is a tricky business and one can not always anticipate ambiguities and the irrationality of the responder! Sixty percent of schools surveyed responded with 68 individual teacher responses. The questionnaire was divided into sections asking for information on Science teacher experience, teaching resources, Science curriculum issues related to the Planet Earth and Beyond strand, and teacher 'Geological knowledge'. Only thirty eight percent of teachers surveyed responded to the optional Geological knowledge 'test'. Another customised questionnaire was given to the Science staff at a teacher training College of Education and to teachers in training (both primary and secondary). The Geological knowledge 'test' was the same for all groups. These 'test' results alone form the basis of a separate paper, but space does not permit a full discussion here.

Summary of Questionnaire Responses
The Curriculum
Somewhere between 10 and 15 hours of teaching time is given to the year 11 Earth Science component

of the Planet Earth and Beyond strand with about 3 hours given to the Astronomy component. Most schools provide about 7 hours at year 9 and 10 hours at year 10 for the Earth Science component. About 8 hours at year 9 and 5 hours at year 10 are given to the Astronomy component. A recent (July 1998) survey at an in-service course suggests that time allocation for Earth Science teaching has still not increased and is about 40% less than that required by the curriculum. An analysis of the course structure for Science 306 at a major College of Education shows that the Planet Earth and Beyond strand receives 48% less tuition time than Physics, Chemistry and Biology. Entry to this main Science teacher training course for graduates is a pass in any 200 level university science subject.

There is debate about the best 'curriculum niche' for Astronomy: - some want to leave it out and do this topic by project, some say it detracts from developing interest in the Earth Sciences and others say it makes little difference what you do with it. The philosophy of coupling Astronomy with Earth Science is to allow students to see that *our planet* has a place and a history within the universe.

Amongst many other questions, teachers were asked to rank their perception of the level of difficulty (from 1 to 4) for each main Earth Science topic at year 11 level. They were also asked to identify the kinds of difficulties their students had at each level of the Earth Science section. The results in table 1 shows the number of responses for teacher perception of 'topic difficulty'.

Table 1.

Year 11 topics	R 1	R2	R3	R4
Geol. time and history	4	3	3	3
Rock and mineral ID/class'n	8	4	1	0
Investigating rock types	0	5	4	2
Reporting on Geological resources and assoc. issues.	4	1	3	6

From Table 1, it appears that teachers lack confidence (and training) in identification of rock types and minerals and consequently doubt their ability to pass on their understandings to their students. There is also poor understanding of geological time and how it is investigated scientifically. Teachers are more confident about geological resource issues, perhaps because of the general knowledge, environmental and 'Biological Science' nature of the topic. There is some criticism however, that inclusion of 'natural resources' and associated issues into the science curriculum is too 'geographical' and social sciences oriented and therefore not really part of a Science course. On the other hand, teachers committed to an *Earth Systems* approach are likely to applaud it!

One of the more disturbing responses of teachers, concerned attendance at Earth Science in-service training courses. About thirty percent could not remember or had never attended an Earth Science in-service course, but when they are offered, they are always popular and worthwhile. Eighty six percent of respondents said they need and want more Earth Science training! When teachers were asked to describe their confidence (table 2) in teaching Earth Science, the following results were obtained. It is not surprising there is a demand for training.

Table 2.

Terrified	Poor	OK	Fine	Good	Brilliant
1.5%	17%	37%	21.5%	20%	3%

When questioned about attitudes towards teaching the Earth Science component (table 3), the following results were obtained. These results are simply the number of responses recorded for each category not percentages.

Table 3.

Year level	Hate	Dis-interest	Interest	Enthus-iastic	Very. Enthus-iastic
9	1	7	26	12	1
10	2	11	31	15	1
11	3	12	29	15	2
12	0	10	1	2	3
13	0	10	0	2	3

Secondary School Science Teaching Experience

Ages for practising secondary school Science teachers from the Canterbury province, ranged from 61 to 25 years with a median age of 45. Sixty six percent were male. The median teaching time experience was 18 years with a mode of 24 and a range of 1 to 34 years. The most disturbing fact was that 28% of the sample have ten years or less of actual teaching experience. The future problems of an aging teaching force are well known! On the other hand, high school students in the Canterbury province have the debatable honour of being taught by highly experienced teachers!

An attempt was made to gather information on the qualifications of Science teachers. Only one out of the 68 was a non graduate, 53.5% held Bachelors degrees, 21% held honours degrees, 8% held Masters with and without honours and 3.4% held Doctorates. Of the one class of graduate secondary teacher trainees surveyed, only one was a graduate in geology. Rounded percentages for degree subject majors are:

Physics = 16%

Chemistry = 22%
Biology = 46%
Geology = 5%
Others = 11%

In an independent national survey, for the NZ Geological Society (Lee, 1995), 8% of secondary Science teachers were Geology graduates. As in most other countries, it is relatively uncommon for geologists to find a career in secondary school teaching and as a result, the Earth Sciences are taught mainly by non-specialists. This helps ensure a low profile for the Earth Sciences within school curricula.

School Resources

Although textbooks are still the dominant resource type, questions concerning computing resources revealed that although there were about 33 computers per school (dominated by the PC platform), Science departments make very little use of them. Reasons for this include teacher competence, appropriate software and school teaching scheme implementation difficulties. The following list shows the top five resource priorities.

Practical experiments
Rock and mineral sets
CD-ROM material
Maps
Fossil sets

Teachers essentially want 'something useful for the kids to do on Monday morning'

A Profile of First Year University Geology Students

For the 1997 cohort, ages ranged from 17 to 43 years with a mean of 20.46 and 36% female. For the 1998 cohort, 44% were female and the mean age was 19.75 years. It is notable that single sex schools for the 1998 cohort supplied a higher proportion of students. That is, 48.7% of students were supplied from single sex schools, which was 38% of all schools. Typical reasons for students choosing geology as a subject of study include:

'I was good at geography'
"Provides a subject alternative"
"Friends did it"
"I am interested in volcanoes"

Geological Knowledge

Geological knowledge for all surveyed groups is characterised by the influence of physical geography courses and 'snippets' of Earth Science gleaned from year 9 and 10 Science. It is too early to assess the impact of the new Science curriculum on student knowledge. However, there is some evidence to show that there is an increased use of knowledge gained from the 1994 introduction of *Planet Earth and Beyond*. There are still large misconceptions and misunderstandings about Earth's structure and history. Indeed, Earth Science is still perceived to be mainly natural hazards (TV influence on floods, volcanoes, dinosaurs and earthquakes?) plate tectonics and a little bit about rocks and less about minerals.

Of all the 'knowledge' questions asked, the most poorly answered were those concerning sequencing a geological history. About 62% had little idea about the laws of superposition and cross cutting relationships. Teachers training college staff and students had a lot of trouble with this question. With this now being part of the curriculum at year 11, there should be an improvement in student answers!? Future studies will tell. Just 57% of respondents were able to provide the generally accepted age of our planet! Perhaps of even more concern was that only 6% of students and 13% of teachers were able to provide a detailed description of the kinds of information a study of fossils would give. Primary school trainees were the group displaying the greatest overall difficulties.

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EdGEO Teacher Workshops - Linking Teachers and Geoscientists to Provide Resources and Support for Earth Science Teaching in Our Schools

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Summary
EdGEO teacher workshops link teachers with members of geological societies to help build a geoscience-literate society from the children up. Workshop programs are directly matched with school curricula, to meet the needs of local teachers by providing them with enhanced knowledge, classroom resources and increased confidence to teach earth science units to their students, thereby nurturing our children's inherent curiosity and interest in the world around us.

The EdGEO Workshop Program
Understanding and appreciation of our planet's evolution and fundamental geoscientific processes serve as a foundation on which society can base wise decisions about how to use our mineral and energy resources, how we maintain and remediate the environment and how we respond to geological hazards. It has been argued (Neale 1992) that the most effective approach to increasing scientific literacy is through school children - particularly those in elementary and junior high schools. If we carefully nurture our children's inherent curiosity and interest in the natural world around us, we will help to ensure that students from kindergarten to high school will readily absorb basic teachings in geoscience.

In many of our schools the earth science units are not taught because teachers have received little formal geoscience education, and have in some cases no access to rock and mineral specimens or other tools vital to effective teaching of earth science. It is essential therefore that teachers have the necessary knowledge, confidence and classroom resources to instruct their students effectively.

In the early 1970's the Canadian Geoscience Council began to address this perceived need and implemented the EdEGO program. The EdGEO program is a national program funded by geoscience organisations and corporate sponsors (primarily the Canadian Geoscience Council, the Geological Association of Canada and the Canadian Society of Petroleum Geologists). Local workshops may apply to the National EdGEO committee for funds up to $3,000 per workshop. From 1996 to 1998 this Canada-wide program has supported 31 workshop for 920 teachers. Eighteen workshops are expected to take place in 1999, in British Columbia, Alberta, Saskatchewan, Ontario, Quebec, New Brunswick and Nova Scotia (Haidl 1998).

Each EdGEO workshop is organised by local geoscientists and teachers, and designed to meet the needs of local teachers and to capitalise on local resources. Workshops typically are directly matched with the local earth science curriculum, focusing on particular areas of interest identified by teachers, and consisting of a classroom and a field component. The workshops use local resources and provide teachers with classroom materials to implement the curriculum units with their students. This process engages and empowers teachers.

The Victoria EdGEO - a Case Study
Earth scientists from the Pacific Section of the Geological Association of Canada and the School of Earth and Ocean Sciences (University of Victoria) met with local teachers and members of the Department of Social and Natural Sciences (Faculty of Education, University of Victoria) to identify priority areas in the British Columbia elementary science curriculum. Grades 2/3 (Earth's composition), 4 (Water), 5 (Natural resources) and 7 (Earth's crust) were identified as grade levels where earth science units were introduced in the curriculum and where there was a need for resources and educational opportunities for teachers and through them their students.

In coordination with the local School Boards, a one day workshop was scheduled for a district-wide teacher professional development day, October 23rd 1998. The workshop was held at the University of Victoria and was funded by the National EdGEO Program, the Pacific Section of the Geological Association of Canada and the School of Earth and Ocean Sciences. Twenty eight Grade 2/3 teachers attended the workshop (limit had been set at 25), with at least twice as many more requesting places. Most of the total cost of the workshop, $Can1078, was associated with the classroom resources (including workshop handout, 26 rock and mineral samples, detailed descriptions of each sample, a mineral identification kit, common rock identification booklet, the South Vancouver Island

Earth Science Fun Guide, EdGEO newsletter, assorted pamphlets and mineral and rock identificaiton sheets) provided to the teachers. Registration for the workshop was free.

The workshop schedule, below, was based on the Grade 2/3 earth science curriculum unit - Earth's Composition, in which the prescribed learning outcomes listed Earth's layers, Earth's surface changes, classification of sedimentary, igneous and metamorphic rocks, composition and formation of minerals, rocks, and soil; and the following objectives.

1. To provide teachers with a background and some hands-on experience in the curriculum topics.
2. To provide hands-on activity ideas to supplement teaching of units.
3. To apply the topics in a field setting, showing how the classroom units may be supplemented by a class fieldtrip.
4. To provide a setting for the sharing of ideas among local teachers.
5. To provide resources for the teachers to take into their schools to facilitate implementation of the units in their classrooms.

Morning - Lab (introduction to key characteristics of minerals and key features of igneous, sedimentary and metamorphic rocks, and hands-on practise)

8.45 Introductions and outline
9.00 - 10.30 Minerals - identification using key characteristics
10.45 - 11.30 Rocks - distinguishing sedimentary, igneous and metamorphic - examination of mineral and rock samples for classrooms
11.30 - 12.30 Hands-on activities
Making sedimentary rocks
Settling and sorting sediment
Volcanoes and viscosity
Foliated food
Fun with fabulous folds
Model of the earth

Afternoon - Field trip

1.00 to 3.00 Field trip to Beacon Hill Park in Victoria to look at metamorphic and igneous rocks, glacial till and erosional features, beach sediment and a midden site.

Evaluation

The feedback from the teachers during and after the workshop was extremely positive. Twenty evaluation forms were returned. Overall rating of the workshop (7 categories from Outstanding to Poor) for 20 respondents, outstanding 12, outstanding/excellent 1, excellent 7.

The hands-on experience was judged beneficial - "a wonderful hands-on experience" "We were able to experiment and learn" "time in the lab doing the experiments was great fun, great learning" "Chance to practise what was taught".

The materials / resources were considered very useful - "the take home supplies were outstanding and encourages one to 'do' it with class right away" "You gave a great handout and clear guidelines" "excellent information and samples" "materials provided (Earth Science Fun Guide is a great resource)""the scientific information about the minerals and rocks" "Can use information and materials right away for a grade 2/3 class""Great hands-on ideas"
"Balance of factual information and hands-on practise"
"Excellent facilities, handouts, resources, classroom ideas, relation to current IEP's"

Several teachers indicated that they had not taught the unit before and now felt they couldn't wait to try the activities in the classroom. Others were pleased to come away with additional ideas and ready-made units for their classroom. Teachers indicated that they could use the information and materials right away for a Grade 2/3 class. One teacher has carried out weekly earth science experiments from the South Vancouver Island Earth Science Fun Guide provided, integrating earth science topics into many areas of the children's learning.

Conclusion

EdGEO teacher workshops link teachers with geoscientists to support the teaching of earth science to children. Offering a combination of directed curriculum-related learning, hands-on practise, activity ideas and resource materials (handout, rocks and mineral samples, mineral identification tools, Earth Science Fun Guide) to teachers appears to be an effective way for geoscience societies to assist in increasing and enhancing the on-going earth science instruction in our schools.

In Victoria repeated workshops need to be offered at the Grade 2/3 level to meet the needs of interested teachers, and workshops need to be developed to focus on the other areas of the curriculum (Grade 4, 5 and 7) which contain a substantial earth science component. We are also looking into the possibility of setting up a portion of the University of Victoria Earth Science Undergraduate laboratory to provide ongoing support to teachers and to host student field trips to supplement classroom teaching.

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Inter-University Co-Operation in Geological Education: The SUGOGG Experience

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The Sydney Universities Consortium of Geology and Geophysics brings together the academic units concerned with geology in each of the four universities in metropolitan Sydney. The consortium was formed in 1991, following a Memorandum of Understanding issued jointly by the Vice-Chancellors of the universities concerned. It embraces the following units:

- School of Geology, University of New South Wales,
- Division of Geology and Geophysics, School of Geosciences, University of Sydney
- Department of Earth and Planetary Sciences, Macquarie University
- Department of Environmental Sciences, University of Technology, Sydney.

The Universities of Newcastle and Wollongong have also been associated in different ways with SUCOGG, although these institutions were not included in the original Memorandum of Understanding that formally established the consortium.

Objectives

Each member department has its own history, its own educational philosophy and its own role in the university to which it belongs. Indeed, the existence of such a healthy diversity is one of the main strengths of geological education in Sydney universities, recognised in a survey by the Australasian Institute of Mining and Metallurgy in 1993. Even so, the role of the geosciences at each member university has, for various reasons, changed steadily throughout the last eight years.

SUCOGG's broad aim is to maximise the benefits gained from collaboration in education and research among such a diverse group, to strengthen further the academic base for geoscience in the Sydney region. More specifically its goals are to:

- Improve the effectiveness of Earth Science courses in the member universities, including provision of increased program flexibility without loss of quality, through co-operative teaching at senior undergraduate (especially Honours) level;
- Strengthen combined activities in relevant areas of research, including joint acquisition of equipment and infrastructure and development of joint research projects and funding applications;
- Develop a unified approach to marketing geoscience as a career to potential students, emphasising factors associated with the discipline itself rather than the individual departments or course offerings involved;
- Facilitate co-operation among Earth Science departments in the member institutions on matters of mutual interest;
- Act as a focal point for interaction with industry and government on geoscience in the Sydney region.

Cross-University Undergraduate Teaching

One of SUCOGG's principal activities is the development and presentation of cross-university coursework modules for students enrolled at advanced undergraduate (Honours) level in the member universities. These were first offered in 1992. The program was re-developed in 1997 to focus on the educational needs of the students and, as a result, a more cohesive series of modules across the main geological disciplines is now in place. Each module is presented wherever possible by staff from at least two member departments. Joint presentation of the modules was intended to access a wider range of expertise and spread the teaching load, as well as to provide backup in case of illness or other staff commitments. It was also intended to ensure continuity of the program despite absences of particular staff members on more protracted activities such as study leave.

Each module typically involves 25 to 30 hours in total of direct teaching, which may include field excursions, computer activities or laboratory studies as well as traditional lecture and tutorial sessions. The number of modules a student may study varies due to the different requirements of the Honours year at the different institutions. For some departments coursework plays a relatively minor role and thesis studies form the main component of the Honours program; for others a coursework program, including SUCOGG modules, may represent up to 50% of the Honours year activity.

A total of eleven cross-university modules were presented in 1998, with enrolments ranging up to 16 students in each. Topics ranged from field-based sessions on convergent-margin tectonics and coastal environmental assessment to computer-based sessions on geostatistical data analysis seismic reflection interpretation. The program enables students to take advantage of expertise in a wider range of fields than would be available at a single institution. It also encourages students and staff from different institutions to interact with each other, improves the students' networks on graduation, and provides a stronger basis for collaboration in research and other activities.

Cross-university teaching has also been carried out in some of the more junior years of the undergraduate curriculum, with subjects presented in one member department for students from several different universities. This has, however, proved more difficult to organise than the Honours-year modules. Problems affecting cross-university teaching at earlier stages of undergraduate courses include differences in the academic year at the different institutions and different subject requirements in terms of contact hours or credit points. Another major problem is the difficulty of timetabling the relevant components in a way that will allow students to undertake other necessary subjects at their home institution; this is exacerbated by the travelling times required to move between the different campuses involved.

Each member university maintains direct responsibility for its own students, including entry, progression and graduation standards. SUCOGG's role is to allow its members to deliver selected parts of their curricula more effectively, and to make better use of the increasingly limited resources available at the individual institutions to cover the full range of geoscience fields.

The collaboration engendered by SUCOGG through these arrangements is supported largely by the professional goodwill of both the member departments and the individuals concerned. It has been assumed that over time the teaching contributions of individual staff members and departments will be spread equitably. However, recognition of individual member contributions is an area of some sensitivity, especially given the shrinking resources and increasingly competitive nature of the Australian university environment. Different mechanisms exist for distribution of funds at departmental level in the different universities, and to some extent this also discourages wider use of cross-university teaching arrangements.

Collaboration in Research

SUCOGG has provided a very successful basis for acquisition of research infrastructure and equipment, which is shared by member universities for student projects, higher degree studies and staff research activities. Infrastructure funded by the Australian Research Council from joint applications sponsored by SUCOGG includes a range of geophysical equipment, an X-ray fluorescence analysis unit, a laser-Rahman spectrometer and isotope laboratory facilities; funding for a soft-sediment coring and analysis facility is currently under consideration.

A series of symposia have also been held, highlighting the research achievements of SUCOGG members and other groups in the Sydney region. These include an early series dealing with ore deposits, fossil fuels, engineering and environmental geology, and geology in the community, a major symposium on the geological development of eastern Australia and a recent symposium on the geology of the Botany Basin. The symposia provide a valuable source of interaction both within SUCOGG and between SUCOGG members and colleagues in the wider community. They also provide an on-campus medium for students to improve their understanding of geology and its applications.

In conjunction with the Universities of Newcastle and Wollongong, the SUCOGG universities have also organised a series of workshops, under the heading "Geoscience NSW", at which postgraduate research students are invited to summarise the progress of their thesis studies. These provide a valuable basis for interaction among the students, and a venue for public testing of ideas without the pressure of a major scientific meeting. More recent workshops have included poster sessions as well as oral presentations, with awards being made in different categories for particularly outstanding work.

SUCOGG and the Future

Shrinking financial and other resources at Australian universities, especially in the sciences, are placing increased pressure on staff to teach in areas of geology in which they have limited or no expertise. This will ultimately require increased time to be spent in course preparation, or alternatively will encourage institutions to drop key areas of study from the undergraduate geoscience curriculum. It will also provide less opportunity for staff to pursue research to complement a high level of university teaching, or to supervise innovative final-year undergraduate and postgraduate research projects. Limitations on research activity will also impact in time on the total resources available to the individual departments, through reductions in research grants and in research-derived university funding components.

Co-operative teaching through SUCOGG provides a mechanism to counter this trend, allowing specialists to share their expertise across a number of institutions and hence maximise the efficiency of the total teaching effort. While some of the academic time saved will be used for course co-ordination and administration, additional time should become available for research-related activities. Experience to date suggests that collaboration in teaching will, as a by-product, encourage closer contact between the institutions, increasing the extent and diversity of collaboration in both teaching and research activities.

Based on recommendations arising from a review of SUCOGG in 1996, the consortium is attempting to secure funding for the appointment of a part-time Director, appointed at professorial level, to co-ordinate and extend the consortium's collaborative activities. This would provide a more effective basis for strengthening the cross-university components of the individual institutions' teaching programs, and also act as a single focal point for interaction between SUCOGG and the professional community, including the minerals industry. It could also allow more effective extension of SUCOGG's collaborative teaching to cover postgraduate coursework activities as well as senior undergraduate programs, and strengthen the research linkages among the member departments.

Field teaching – just a nice day in the sun?

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It has long been recognised by Geoscience educators that field based education provides some of the most valuable and enjoyable educational experiences that our students encounter. Our own experience and anecdotal evidence from literature demonstrates how pervasive this "feeling" is, but vague beliefs in the value of field-based education are not enough to defend it from the "bean-counters" and bureaucrats that dominate current university education policy.

As educators, we are all familiar with the flash of understanding that students show when they are standing at an outcrop and they suddenly comprehend what we have been telling them in the classroom for months. A survey of Geoscience course coordinators and lecturers conducted in 1995 at Macquarie University, showed overwhelmingly that lecturers believed field teaching was not just a "useful additional teaching activity" but was "an essential component of the course" (97% of respondents), and was "necessary to develop all or some of the main ideas or concepts of the course" (91% of respondents). In Geology and Physical Geography courses at Macquarie University the conviction of the value of field-based education is backed up with the allocation of student marks to field work; 0-25% of course marks in first and second year courses, and 26-75% of the marks in third year, honours and postgraduate courses were based on field experiences.

Industry is also interested in the enhanced comprehension that field experience brings to students; instance an article in Geotimes (Anon. 1997) where a US university lecturer was asked to provide field classes for recent employees of an oil company, who, despite having graduate degrees, lacked "appreciation for the scale and three dimensional complexity" of the structures that they were modeling on the computer.

The attack on field teaching

Field teaching has been under attack for some time. Increasing student-staff ratios, time constraints within departments, problems with getting enough experienced staff, and budgetary limitations have all contributed to the problems of running university field trips. More worrying, however, is the perception by bureaucrats and tertiary education specialists that field-based education is a nice adjunct, but not really necessary for students, and worse still is expensive to run. In some instances field-based education is seen as similar to laboratory teaching, which has been attacked for being "inefficient", "ineffective" and for a tendency to "emphasise low-grade skills, to reduce student responsibility, and to foster a superficial and mechanistic approach to relations between theory and practice" (Beard & Hartley 1984). Many of the studies that criticize laboratory classes are based on studies conducted in the 1970's; the disturbing aspect of these charges is that they can be found in 1990's text books about tertiary teaching (e.g. Ramsden 1992), further fueling the perceptions of inefficient and ineffective teaching in the sciences.

Unfortunately, while there are a number of very good papers on field-based teaching in the literature, most of these are based on secondary schools and are subject-specific. An examination of papers on tertiary, field-based education in the ERIC database from 1981 to 1997, revealed 20 relevant papers; 80% of these gave details of how the courses and/or field components of courses were run (some with a vague mention of experiential education), 10% explored educational theory and rationale, and 10% investigated the value of field-based education. All of these papers are valuable resources for tertiary teachers, but there are too few that analyze the educational rationale behind course design and practice, and fewer still with empirical data; such studies are necessary to prove to bureaucrats and other tertiary educators that field-based education is essential for Geoscience students.

The UK experience

The problems with field based education are not restricted to Australia. Clark (1996) found that the traditional pattern of higher education in the UK was in "terminal decline" due to a rapid and recent switch from elitist to mass higher education. A new institutional structure arose as a result of the Further and Higher Education Act of 1992 which eliminated the division between universities and polytechnics and colleges. In 1960 there were 32 universities compared with 92 in 1994. This resulted in large numbers of student, not matched by funding, and a need to recruit and educate more students for less money.

The Higher Education Funding Council for England funded the 1994 Review of Teaching and Learning in the Field, and this combined with the new Teaching Quality Assessment (TQA) systems as well as new research methodologies available (which in part invalidate traditional field practice) led to extended reassessment of field teaching in the UK. The most significant changes in previous 15 years were the integration of skills with fieldwork; the growth of student numbers with wider range abilities; and increased budgetary constraints with the transfer of cost to students or parents. In addition, changes to school curriculum over past 30 years meant that fieldwork exercises previously used at degree level were now entering the school curriculum. (Kent *et al* 1997).

Added to this was a rising student:staff ratio (Clark 1996). An unpublished survey (Higgitt 1993) of thirty UK departments found changes in fieldwork programs including higher student:staff ratios than 5 years preciously, a shift in teaching load to other staff, especially postgraduates, and a reduction of compulsory fieldwork and length of fieldwork. Fieldwork was also most subject to changing transport and health and safety requirements (Gardiner 1996).

Clark (1996) suggests that the new context of fieldwork offers scope for innovation and change. Clark suggests a shift in emphasis from teaching in the field to learning in the field; the use of fieldwork to develop a wide range of technical, attitudinal and enterprise skills; the introduction of innovative methods of assessment and the encouragement of student centered study and work groups. He suggests making use of the local area rather than more expensive alternatives.

The key issues facing fieldwork were identified by Kent *et al* (1997) as

1. the need to evaluate various methods of field teaching and their effectiveness;
2. the need for a "progression" in teaching - i.e. from first year "look-see" through to final year group work;
3. preservation of small-group teaching;
4. problems in financing;
5. gender issues – male bias in lecturers, trips organised by men;
6. specialisation in fieldwork vs broad understanding;
7. the relevance of preceding fieldwork experience to a major project or dissertation;
8. the effectiveness of assessment;
9. the effectiveness of computer technology.

Objectives of field-based education

The Higher Education Study Group Meeting (UK) (1994) identified three general categories of objectives of field work: subject specific (i.e. integration of subject theory and practice, teaching of techniques, exposure to "real" research, etc.); transferable/enterprise skills (i.e. independ-ence of thinking, enhancement of present-ation skills, development of group work skills, etc.); and socialisation and personal development (i.e. stimulation of enthusiasm for study, respect for the environment, getting to know staff/students, etc.) (Kent *et al* 1997). To these categories we can add the promotion of "deep learning", an understanding of scientific approaches and methods, comprehension of the strengths and limitations of science, perception of the interconnection between knowledge areas, and preparation of students for future employment.

There is, however, a lack of systematic empirical evaluation of effectiveness of fieldwork

Educational rationale

The educational model under which the UK geographers and, indeed Australian Geoscience educators, based their fieldwork has changed since the 1950's, when the "Cook's Tour" was in favour. In the 1960's, a revolution in education prompted a change to field work that was problem-orientated, project-based, and incorporated group-work (cooperative-collaborative), which continued through the 70's and into the 80's when transferable skills became important. In the 90's, a large growth in student numbers has led to a variety of models, culminating in the late 90's, in the cost-effectiveness of computer simulations being examined.

Unfortunately, few Geoscience educators have a clear understanding of the educational philosophy that underpins their field teaching and course design. In general, most would use their prior experience as students and educators to determine what students should do in the field, and how this should be organised.

In general field-based courses can be viewed under the broad philosophy of "experiential learning" or "experience based learning"(e.g. Manning *et al.*, 1998), but there are a number of teaching/learning strategies that can be used under this umbrella. These include problem-based learning, cooperative/collaborative learning and contextual learning.

A survey of lecturers and course coordinators of Geoscience education at Macquarie University showed that most of the course design and practice unconsciously parallels the contextual learning model proposed by Coles (1990, 1991). This model focuses on "elaboration" as the most important goal i.e. seeing the interconnections between different knowledge areas, and between theory and practice. When Macquarie Geoscience lecturers were asked about the unique benefits that students gain from field teaching, 100% of lecturers of first and second year, and 94% of third and higher years agreed that "it encourages integration of the practical and theoretical aspects of the course", whilst 97% of lecturers held the view that field work "allows students to apply theory to the real world".

Coles (1990, 1991) contends that there are three preconditions for effective learning: an appropriate concrete context, the provision of relevant abstract information, and an opportunity for students to handle abstract information and relate this to the "real world" (Coles uses the term "clinical practice"). These preconditions are generally met in field based education.

In Geoscience field-based courses at Macquarie, most, though not all of the second year and higher level courses use small groups as the organisational tool for field teaching. These groupings can also be used in cooperative and/or collaborative strategies; however, lecturers consistently rated the skills needed for cooperative/collaborative learning (e.g. working in a team, learning to organise themselves etc.) as having a lower priority than many other skills. Thus it appears that many Geoscience educators are not convinced about the benefits of true cooperative learning - often it comes down to the most basic of questions, how can the results of this style of learning be assessed?

Field teaching in the new millenium

It has been suggested that to save money, field-based education could be replaced by computer simulations. Computer simulations can be a valuable educational tool for some situations, and to teach some points, but they can never replace the educational experience of going to the field. Any computer simulation, or indeed a video or slide show, can only be an abstraction of reality, and, by necessity a simplification of reality. Lonergan & Andresen (1988) list 5 things that can only be experienced in the field: 1) demystification - where students can actually see and finally understand something e.g. a "bed"; 2) holism - seeing the whole setting/context; 3) originality - collecting original information and impressions; 4) integration - where separate fragments of information are integrated into a coherent whole; 5) tacit knowledge - getting the feeling or "nose" of the experienced observer. Which of these aspects could our students do without?

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Teaching " Foundations of Natural Sciences II" to University of the Philippines Students

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The University of the Philippines College Baguio requires all its non Science degree majors to enroll and take the general education subject known as Natural Sciences II (Nat. Sci.II) otherwise known as Foundations of Natural Sciences II. This is a three unit course which focuses on the fundamental concepts, principles and theories of earth and life sciences. The prerequisite for this course is Natural Sciences I which teaches concepts in Chemistry and Physics.

The teaching of Nat. Sci. II course to non Science majors is cognizant and consistent with the objective of the university in providing students with a well rounded education by offering a variety of general courses that will provide them with basic knowledge and skills for meaningful social interaction. The university has assumed that since the students taking this course are mostly those who have aversions to or are not interested in the natural sciences, the teaching and syllabus of the course were therefore designed to appeal as well as become stimulating to this particular group.

The course is divided into two. The first part is the teaching of the fundamental concepts in Geology while the second part is the teaching of the fundamental concepts in Biology. This course is team taught by a Geoscience teacher and a Biology teacher. The grades that the students acquire in both subject matter are added and averaged to constitute the final grade for the whole course. The teacher of each subject matter is given approximately 28.5 school hours or an equivalent of 28.5 meetings of the whole semester to discuss the entire content of his syllabus. As such, there is a need to condense all of the topics in a way that is easily understandable and interesting.

Among the general objectives of Natural Sciences II are that at the end of the course, the students 1) must have a comprehensive, integrated and synoptic understanding of the concepts, principles and theories of the natural sciences and 2) appreciate the natural world within the context of the concepts and theories discussed in the course.

For the Geology portion, the specific objective is to understand and appreciate the concepts and principles related to the effect of the various physical forces shaping the earth and geological time.

To impart these objectives to the students, the Geoscience teacher usually employs a variety of teaching methods. Among these methods are lectures, film and slide showings, demonstrations and field trips. Lectures are always aided with visual aids like acetates that are shown through an overhead projector. Sometimes, block diagrams are drawn on the board to emphasize very important points. Film showings are accompanied by "guides to film showing", a mimeographed copy containing basic terms and concepts discussed in the film. The students refer to this guide as the film unfolds. Slide films are shown to emphasize some examples of basic geological processes and evidences found in the Philippines. It is thought that a colored and actual depiction of geological concepts through films and slides makes the teaching of the course more interesting to students. In instances where actual demonstrations are needed, the teacher makes use of certain instruments to prove his point. For instance, the teacher demonstrates to his students the actual way of measuring the attitude of a sedimentary bed by showing a real Brunton compass and manipulating it to show how the strike and dip are determined. This way, a fairly abstract idea is made more understandable. Field trips are scheduled on a non-class day, usually a Saturday. Field trips provide a respite from classroom interactions and enable the students to become in contact or see in person what has been discussed in the classroom. During field trips, the students are sometimes brought to an ecological tour of nearby areas, an underground mine tour or a tour of a road which shows outcrops of different kinds of rocks. The financial capability of the students as well as the distance from the university are two factors which have been considered in choosing the areas to be visited. The following are the usual field trips that the Geoscience teacher makes available to students.

Within the vicinity of Baguio City is found the Maryknoll Ecological Sanctuary. This was formerly a convent of the Catholic Maryknoll sisters but which has since been converted to a sanctuary protecting many Pine trees and exotic flower bearing plants. The sanctuary was constructed in such a way that a tourist goes through a maze of landmarks which corresponds to the different subdivisions and important events of geological time. The tour is conducted by a nun and the Geoscience teacher just assists in the needs of the group. The tour begins when each student is made to pass through a cemented arch signifying the birth of the universe as conceptualized by the Big Bang theory. After passing through the arch, the student is now brought 4.6 billion years back to signify the time when the earth evolved from the materials of the solar nebula. Then begins the unfolding of the earth's physical history when the tour guide leads the students to different "stations" (complete with symbolic edifices) to explain the evolution of the 1) oceans, by pointing to the Lingayen gulf of Pangasinan from the peak of a hill 2) the mountains, by pointing to Mount Santo Tomas which, from a vantage seems adjacent to Lingayen gulf 3) and the earth's atmosphere by explaining the formation of clouds, dew and fog which are seen during the early morning tour and for which Baguio City is well known for. The remaining half of the tour is now devoted to the evolution of life on earth, beginning with the most primitive ones up to the dawn of man. The tour ends with the birth of ancient civilizations. The nun who conducts the tour injects some spiritual meaning to the existence of the universe and everything in it while the Geoscience teacher supplements the activity with geological facts and figures. The Geoscience teacher has time and again observed that the students are awed by this kind of presentation (of nature) and become revitalized and energized when they go back to the classroom. They then become more prepared to study other geological concepts.

At other times, the students are made to tour the underground mine of Benguet Corporation, situated about 16 kilometers southeast of Baguio City. This gold mine stopped operating in 1992 and has since been converted into a tourist destination. One portion of the fortuitous tunnels of the mine was developed into a safe passageway simulating the ambiance and the operations of an operational underground mine. Here, the students are made to wear miner's gear and made to walk about 2 kilometers underground. They are also shown how underground mining is done. They are made to ride mine cars and they are shown how blasting is done. The process of milling and refining gold are also explained as they are brought to the gold mill. This experience opens the minds of the students to the importance of mining to people, civilizations and progress. This activity gives the Geoscience teacher the opportunity to discuss environmental issues related to the physical environment.

Sometimes the students are given a tour of a roadside where different rock units outcrop. The most common area of interest is Kennon road, situated south of Baguio City and one of the vital arteries going to the city from Manila. Here, the various sedimentary rock formations are shown to the students. While at it, the dips of the beds as well as their characteristics and the various fractures and joints are pointed out. Finally, a brief description of the history of formation of the different rocks with special emphasis on the geological events and upheavals which took place, is explained. This activity brings the students closer to actual geological history and enables them to appreciate the concepts of rocks, minerals and geological structures because everything seems to be just right at their backyard.

As aforementioned, to ensure that the students taking the course are inspired and stimulated to learn, it is equally important that a concise and easily understood syllabus be made to conjunct the method of teaching of Nat. Sci. II. This is why the course begins with a discussion on the beginning of the universe, the birth of the galaxies, of the solar system, the planets, as well as the other planetary bodies. This provides a brief introduction to Geology and also serves as a transition that will summarize and review the few science concepts the students have learned in secondary school.

After the foundations of the beginning of time have been laid down, the students are now shown the structure of planet earth in which they live in. Here, the evolution of the earth's lithosphere, hydrosphere and atmosphere is discussed. Now that the Geoscience teacher has prepared the students, thereafter, they are taught the different materials of the earth like minerals, rocks and water. To enable the students to appreciate the importance of these materials, they are made aware to the fact that all of the things that modern day civilizations enjoy are the results of the recycling of these materials. It is by pointing these out very distinctly that the students get to appreciate the value of discussing these topics. After the first portion of the syllabus has been discussed, the Geoscience teacher now moves on to the endogenetic processes taking place on earth. Among these are the very basic and important ones like plutonism and volcanism, plate tectonics, folding and faulting. All of these processes are linked to the topic of earthquakes. An exhaustive and clinching discussion on earthquakes is then made. Special emphasis is made on volcanism and earthquakes because the Philippines frequently experiences these phenomena. These topics have also been observed to be the most interesting to students because they can very well relate with them. In fact, most of the questions in this subject matter are concentrated in this these topics. This also becomes the most effective time when some concepts on Environmental Geology are analyzed and imparted to students. After the discussion on endogenetic processes, the students are now taught principles of exogenetic processes like mass wasting and sedimentation. Then, everything that has been discussed is now related to the concept of geologic time (through a discussion of the geologic time scale, geologic column and geologic dating) and evolution. A brief explanation of the geological mapping procedure is also made. Whatever kind of topic is discussed, the Geoscience teacher always begins his explanations of the concepts with examples that parallel each person's experiences in his life. This is to ensure that these concepts are given definite dimensions and abstractions are avoided. The technical discussion may now follow in detail.

The following is a copy of the entire concise syllabus of the Geology portion of Nat. Sci. II that guides both the teacher and the students.

A. FORMATION OF PLANETS 2.5 hrs.
   1. Planets: Characteristics and theories of Origin
   2. Asteroids, meteorites and comets

B. EVOLUTION OF PLANET EARTH4.5 hrs.
   1. Atmosphere: Early to Present features
   2. Hydrosphere: Early to Present features
   3. Lithosphere: Early to Present features

C. CHARACTERISTICS AND DYNAMICS OF THE EARTH .....21.5 hrs.
   1. Materials of the earth and their recycling
      a. Minerals b. Rocks c. Water
   2. Geological Processes and Consequences
      a. Endogenetic
         i. Igneous activity – volcanism and plutonism
         ii. Metamorphism
         iii. Folding and Faulting
         iv. Plate tectonics theory
      b. Exogenetic
         i. Weathering and soils
         ii. Erosion & erosional agents: streams, groundwater, glaciers, wind, ocean waves and currents
         iii. Mass movement of rocks and soil
         iv. Sedimentation
   3. Geological Sequences and History
      a. Principles of Historical Geology
         i. Uniformitarianism
         ii. Laws of Superposition, Original Horizontality, Lateral Continuity
         iii. Laws of Faunal Assemblage and Faunal Succession
      b. Geologic dating: Absolute and relative
      c. Geologic column, geologic time, geologic maps
      d. Physical and biologic event through geologic time
   4. Earth resources: Origin, development and conservation

The semestral evaluation of the faculty (teaching the Geoscience course) by the students, has revealed that the above mentioned style is effective.

Positive feedback on course content and manner of presentation are consistently obtained. More than anything else, dynamic outdoor activities and emphasis of the relevance of geological concepts to daily living, inspire the students to become willing and diligent recipients of knowledge in Geoscience.

Minerals Council of Australia: National Education Program

Dianne Stuart

Assistant Director - Education,
Minerals Council of Australia

The National Education Program of the Minerals Council of Australia has been specifically designed for primary and secondary teachers. Features of the Program will be demonstrated, along with online viewing of new geoscience teaching materials and the CD ROM education package -*Elemental.*

The Program is delivered throughout Australia by a minerals industry education team based in each State and Territory. It offers a range of activities and educational resources to promote the teaching of geoscience in Australian schools and provides information about the minerals industry.

Activities include -

- Curriculum-based presentations delivered in schools or dedicated minerals education centres
- Tours of mining and processing operations
- Teacher workshops demonstrating the latest minerals related educational resources available
- Seminars for secondary students
- Access to teaching and learning activities and resources across a range of topic areas and issues relating to the minerals industry.

The needs of Indigenous students are being addressed via a soon-to-be-released kit - *Our Land: Our Future.*

Tapping into the services offered under the National Education Program can be done by phone - 61 2 6279 3600, email - info@minerals.org.au or via the Council's Website.- **www.minerals.org.au**

Concept Maps & Constructivism in Developing an Introductory Structural Geology Course

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For the past several years we have been changing the way we teach structural geology to undergraduate geology students. Two principal modifications to the way we deliver material to students have resulted from our work which was undertaken to try to achieve more meaningful learning in our students (Ausubel 1963; Ausubel 1968; Ausubel, Novak et al. 1978). One is the direct delivery of computer developed material during lectures (James and Clark 1992), and the second is the use of concept maps, which is the topic of this presentation.

The use of concept maps in our teaching to encourage students to adopt a deep/holistic approach to learning and to develop a better understanding of the concepts of structural geology is described. Although structural geology is a topic in most introductory courses, its treatment in second year undergraduate courses involves many new concepts. An attempt has been made to present these concepts most effectively by using concept maps as a teaching tool and a learning tool and in curriculum planning. The outcomes of this approach will be described.

The subject that we were teaching was one of the first topic specific subjects that the students encounter after the overview introductory geology subject that is taken in the first year of their course. Most of the students intend to major in geology and so the content of this subject is fundamental to their understanding of future studies in geology.

Structural geology at this level is 'concept rich', introduces a 'new language' and contains both theoretical and descriptive components. It also became clear to us that the apparent logical sequence for the presentation of the topics did not take into account students' prior knowledge. Another problem with the teaching of this subject that we wanted to overcome was the difficulty students have in the early part of the subject in seeing the 'big picture'.

In trying to address these concerns we found that concept maps were a very useful tool both for us as subject designers and for the students to help them organise their learning. Concept maps provide a good means for showing the way individual concepts fit into the big picture and provide an image of the way new material links with the knowledge that students already have.

The use of concept maps to develop the subject content resulted in a change in the order of presentation. We found that by trying to link topics and concepts to provide the big picture there was a more logical sequence for the order of presentation than that which we had been using in the past; a sequence which was similar to that of most structural geology textbooks.

Another outcome of this approach was an overall reduction in the content of the subject. We emphasised ideas and thinking skills at the expense of specialised vocabulary and mathematical proofs and we chose sets of ideas that built on prior experience.

The results of the modifications were evaluated using a variety of methods. Reflective journals were inroduced to try to track patterns of student learning and end of subject evaluations were used via anonymous questionnaires, focus group interviews and structured interviews with individual students. The interviews were carrid out by an independent person from another faculty who had had no previous contact with the students. We also compared student exam results with those of students from previous years.

Our overall conclusion was that students were just as competent as in previous years (their exam results were better) and were more likely to retain the knowledge that they had acquired.

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Geotourism, a new perspektive for public awareness on geolgy

Case study GEO-Park Gerolstein & GEO-Centre Volcaneifel, Germany

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In the early 80th of the 20 Century in volcanoeifel, an area that is situated between Cologne, Coblenz and Trier at the border close to Luxemburg, geotourism was initiated by the Geological Institute of the Rhenish-Technical University of Aachen. With scientific support of Professor Dr. W. Kasig the first GEO-Trail in the Eifel region was build up and finished in 1988. The first finished GEO-Trail in Hillesheim, realized by Dr. I. ESCHGHI, had an economic input on one side for the region, as for the first time geological subjects were taken to be basis for touristic promotion and marketing. Second it set marks and gave too way for geology in Germany for explaining and transfering geological themes in the broadest sense to public.

It may sound strange, but in reality geology is non-existent in schools here, except where a teacher's interest lies on geological items. The subject geography in Germany has developed during the last twenty to thirty years towards a direction that emphasized geographical settlement items and other related things. More or less pushed to the end of the row however are items like water cycle, geological processes, rock formation, earth history, dynamic processes in the Earths crust, relevance of rock properties for construction etc.

With the opening of the first GEO-Trail in Hillesheim, Volcanoeifel the door was pushed open to start to present geology from a different point of view: Fascinating

landscape to admire, to relax and to experience in an absolutely new manner.
This activity was followed by building a GEO-Route in Manderscheid (BRAUER 1993), the GEO-Park in Gerolstein (FREY 1994-97) and Museums, here a Natural History Museum in Gerolstein (1986) with emphasize on Devonian reef fossils, minerals, forest and archeology and as future item water. In Gerolstein the third biggest private mineral water company in Europe exists! Further museums are the Iron-Museum (1987), Eifel-volcanism (1996) as well as on Maar-volcanism (1999).

The main aim of local community politicians and their decisions was to build a bridge for guests to spend more time in the region with sensible activities: relax during holidays in nature, to learn about the geological system in beautiful and extraordinary, bizarre landscape and to prepare and forward sustainable development on the growing tourism sector.

Volcanoeifel is part of the Rhenish Massiv which during Palaeozoic times was deformed to a mountain chain. As medium high mountain region, in Volcanoeifel the young geological processes which are witnessed by tertiary and quaternary phases of high explosive maar volcanism with basaltic products on a continent form the basis as positive promotion criteria, especially as there is no other area in Germany with such a young volcanic past. The youngest maar explosion happened 10.000 years before present. So it was no surprise that by presenting new trails across the region, opening new museums to the public and to guests visiting this region the image of geology grew during the past 12-14 years. The region has invested, with support of the European community and the country Rhenania-Palatinate, more than 12 Million DM during this time to build up these infrastructure. Geologists, who worked out concepts and realized this infrastructure were paid by special programmes coming from the agency of employment. Parallel to this development new programmes as geological trips to guide people, to explain this interesting area and to train people as guides, and so on, took place. Since 1996 GEO-Park Gerolstein created programmes for children and a volcanoeifel family with „Willy Basalt“ as symbol figure for transfering geological items to children. Todays activities lie on working on a general structure to establish a GEO-Scientific-Information Centre - (BÜCHEL & FREY 1998, 1999) to make safe that the information on geological research results is steadily renewed. This is suggested to be the base of the general centre for a sustainable future, in collaboration with universities, local economy, authorities and society.

NOTES

NOTES

Section 2

Abstracts for Poster Presentations

HYPERPET: A Web-based Optical Petrology Tutorial Package: Or Quicktime and HTML Come to the Rescue in the Teaching of Mineral Optics

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Overview

The teaching of mineral optics, optical petrology and petrography is a fundamental component of any undergraduate teaching program in geology. Teaching students the critical skills required for the microscopic examination of rocks and minerals occupies approximately half of the available laboratory teaching time in the intermediate year geology course at the University of Sydney - this amounts to about fifty teaching hours at second year level. The B.Sc. pass degree at the University of Sydney is a three-year generalist science degree requiring twenty-four hours of contact per week for six half-year semesters. Our second year geology courses consist of eight contact hours per week in first and second semester. Third year majors in geology go on to take a further four to six hours per week of petrology related courses over the course of two semesters.

The experience of instructors, student responses to class surveys and informal discussions with students all indicated that many students find aspects of optical petrology very difficult. Students indicated this area of their learning presents the most frustrating and the most complex set of concepts and nomenclature that they have to master in their intermediate year. An interesting point raised by students was that they felt that much of their difficulty arose from the fact that students were often uncertain about what, exactly, it was that instructors were looking at when they were describing an optical property such as relief or birefringence. That is, students were often not sure of what point it was in the field of view that their instructors were talking about and looking at. For some students this was despite the fact we know that the instructor was using a clear image projected onto a large screen as well as an appropriate pointer. It would seem that keeping track of the new terminology, the optical physics responsible for the phenomenon being observed, as well as paying close attention to the changing image was too much to cope with all at once. When one thinks back to their first exposure to mineral optics and petrography these reported experiences of varying degrees of confusion, (and in some cases complete bewilderment), may trigger something of resonant memory - it certainly does for one of the authors, TCTH.

HYPERPET

In order to assist our second-year students master the complex tasks involved in the microscopic identification of rocks and minerals we have created a set of CD-Rom based tutorials which focus on the set of practical petrology classes used in second year. There are two modules currently available, HYPERPET - Metamorphic and HYPYERPET - Magmatic while a third, HYPERPET - Sedimentologic is currently under construction. The tutorial package utilises the capabilities of the Netscape Web Browser to present its material as a cascade of hotlinked buttons. Short Quicktime movies of the microscope eyepiece view of thin-sections as they are rotated through a full 360° in both plane-polarised and cross-polarised light provide a perfect way to view the optical properties of minerals. Minerals of specific interest are generally located in the centre of the movie's field of view or are obviously identifiable by their colour.

The HYPERPET package is, in effect, a virtual microscope that comes complete with a library of full-colour Quicktime movies of petrographic slides from the collection the students work on. The Quicktime movies are linked by html and Java-scripts to sets of notes that describe the various optical properties in general and the minerals in particular (Figure 1). A birefringence chart is also provided. Properties such as colour, pleochroism, birefringence, extinction angle and even relief can be clearly demonstrated to students on a standard home computer.

Copies of the package are provided to students on a CD-Rom at a nominal cost and a set of self-assessment tests (Figure 2) has been incorporated into the package so that students can check on their own progress through the course content and concepts at their own convenience. These self-assessment tests are similar in both design and level of difficulty to those given the students during their end-of-semester exams. Our students are used to formative assessments of this type (see Hubble and Dalziel, this volume) and find them very helpful.

The ability of the Quicktime movies to present the variation in the appearance of a mineral as the stage is rotated is an enormous advance over conventional still images provided in textbooks and photo atlases of rocks and minerals. The mineral movies have been digitally recorded using a video camera attachment on a high-quality petrographic microscope. The size of the individual movie-files, two to three megabytes, generally requires a fairly fast computer to play them. The size of these files and current modem speeds has also required that the package be delivered by CD-Rom rather than by placing the material on a server. We find that the minimum machine requirement is to run HYPERPET is a Pentium 75MHZ PC or equivalent. The use of the Netscape browser as the means of presentation in combination with the flexibility of HTML, Java-scripts and Quicktime ensures that HYPERPET is platform independent.

Evaluation

Hyperpet was introduced into second year teaching in 1998. One class of thirty-five students (21 voluntary responses) has been surveyed so far. This survey revealed that the Hyperpet tutorial program was generally well received by students with all students indicating that it helped them learn optical mineralogy to some degree. When asked to rate their perception of the benefit the CD-Rom package provided them on a five point scale 5% indicated it helped them greatly; 43% indicated it helped them a lot; and 29% indicated it helped them a little. All but one student found Hyperpet 'interesting and enjoyable to use' and all students indicated that it was straightforward and easy to use. Interestingly, and gratifyingly, the whole class responded very well to the Quicktime movies of mineral properties with 91% of students indicating that the movies were greatly (67%) or much (24%) superior to still images found in photo atlases.

We are not sure if the use of Hyperpet has improved student learning of mineral optics in a rigorous statistical sense because we have no formal control group. The optical mineralogy class sizes are relatively small and the ability of the group of students in these classes varies quite a lot from year to year. Our impression is that students are more confident when using a petrographic microscope and more successful at identifying minerals. The versatility of the Hyperpet package can only improve their ability to revise, especially as students are not tied to a real microscope but can use Hyperpet's virtual microscope instead.

Figure 1: Details for biotite with links to Quicktime movies in plane polarised light and cross polars (under the little hand at mid-right).

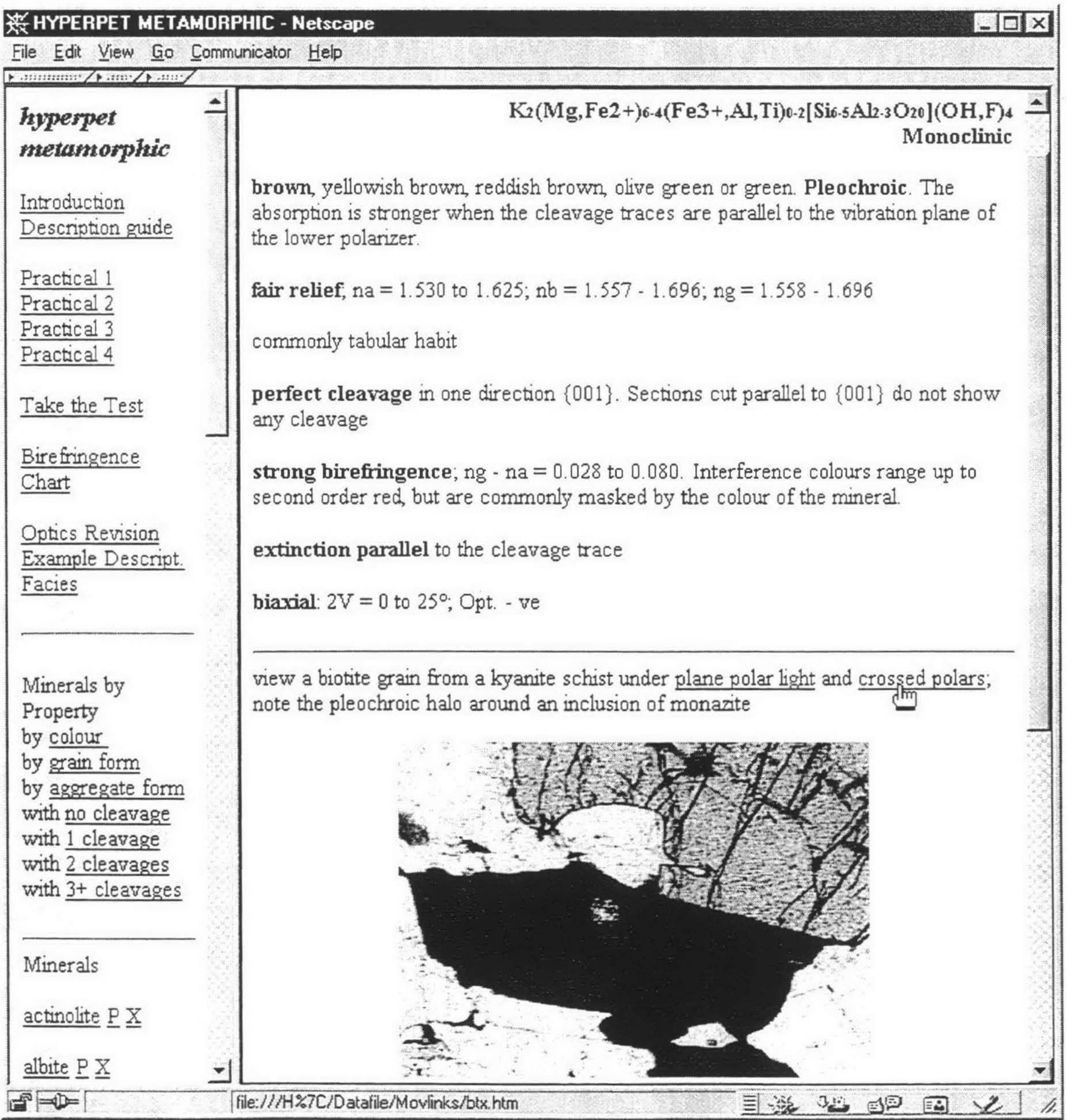
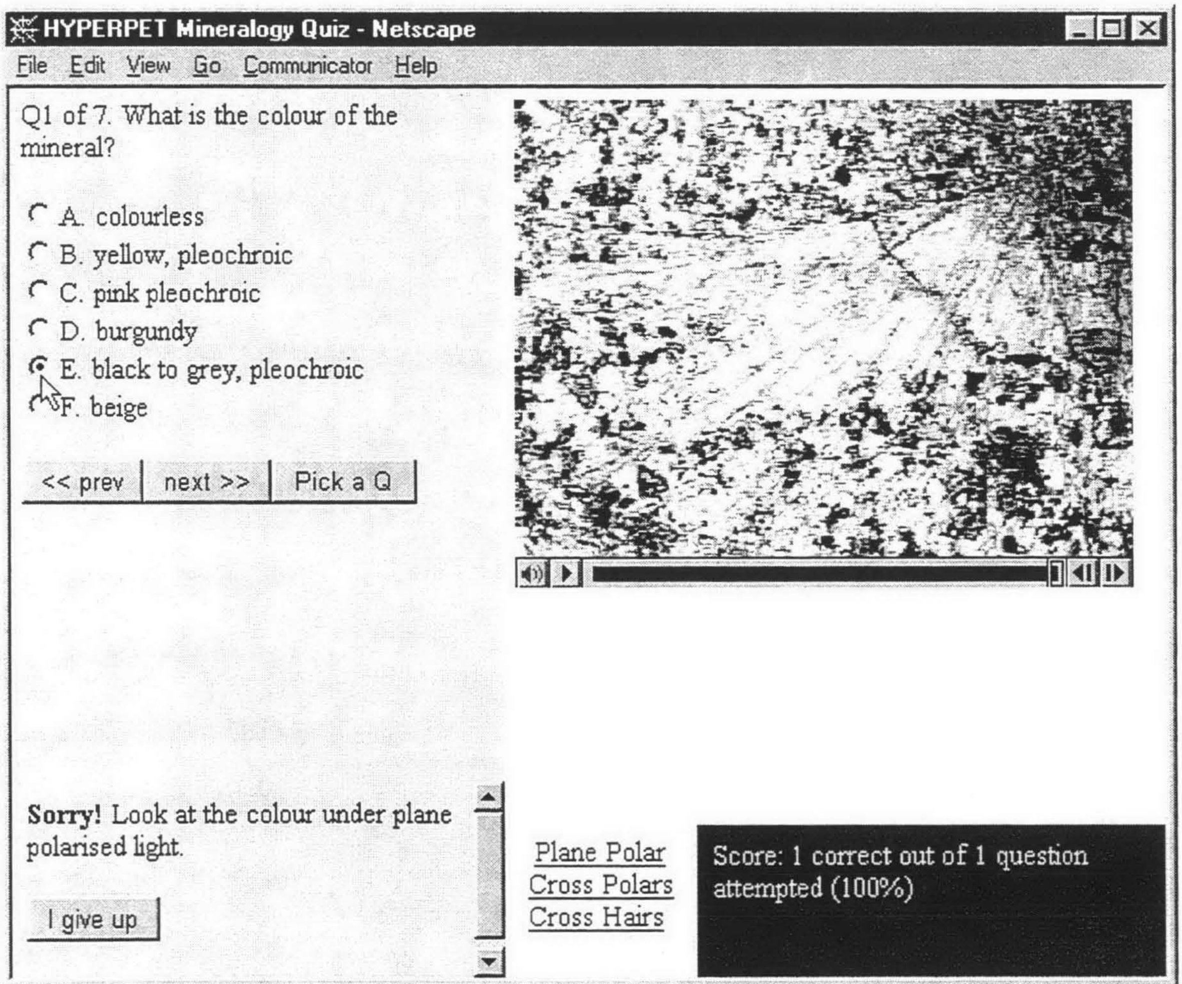


Figure 2: An example of a question from the self-assessment quiz on sillimanite



Earth Systems Science 2000

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Earth Systems Science 2000 stems from a successful project, *Earth Systems and Constructivist Strategies*, piloted in 1998/99 at Longfellow Middle School in Wauwatosa, Wisconsin. As a result of the earlier project, approval was given to include Earth Systems Science in the middle school science curriculum beginning in the 1999/2000 school year. This new project ensures that teachers are trained and students will learn using new educational strategies designed for that purpose. This project will also serve as a template for other schools to use for increasing their earth systems instruction.

Earth Systems Science 2000 has increased the number of teachers formally trained in teaching Earth Systems Science from four in the 1998 pilot project to seven in 2000, with all eleven science teachers teaching Earth Systems Science. Each teacher researched topics, and designed, developed, and created class-sets of materials and equipment needed to teach their unit at their grade level, 6th, 7th, or 8th. *Earth Systems Science 2000* expands our program significantly by increasing the number of teachers designing earth systems units and involving all 1,000 students in experiments at a new field station.

I was responsible for the design and construction of a research laboratory built in a vacant area in the building. This lab, along with an adjacent outdoor area, where students design experiments and work with their teacher, is an ideal, stimulating, convenient, field station for teachers and students alike.

The unique, effective, tested, and successful, professional development program currently taking place is crucial to the project. It involves teachers learning to integrate the branches of science, to write thematic units using constructivist strategies, and also to align our units with the National Science Education Standards and State Standards. Professional development includes unit design of teacher-selected topics, individualized teacher training and guidance in selecting and making equipment, in addition to team teaching experience, which ensures that earth systems science is being delivered and learned by every student.

In-school field trips have been set up to allow our students to study the environment without leaving the premises. Teaching time is gained, which was otherwise spent on a school bus to distant places. The money not spent on transportation is now available to acquire geologists, naturalists, and other professionals to visit and present scientific information and experiments which reinforce the regular curriculum.

Field trips to the new field station from other schools were also designed, teaming a younger and older student. This also allows for team teaching, helping teachers learn from each other.

The approach that I took in order to increase Geoscience Education is in a form to be shared with other teachers around the world. An additional outcome of *Earth Systems Science 2000* for which participants of the 3rd International Conference on Geoscience Education may show additional interest, is the availability of thematic units for use by science teachers anywhere in the world. Units are printed in a standard format with complete data, materials lists, information, and copy-ready masters to be used in any classroom internationally.

Earth System Science for Elementary/Middle School Education Majors

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Introduction:

An explicitly stated theme of the *National Science Education Standards* in the United States is that science is an active process and learning science is something that students do, not something that is done to them. It is generally known that there is no more effective way to convey the excitement of science than for teachers and their students to become actively engaged in the scientific process. By scientific process, we mean the skills of investigation, critical thinking, imagination, intuition, playfulness, and thinking on your feet and with your hands. These skills are not just limited to scientific inquiry, but promote freethinking and creative approaches to problem solving that can be incorporated into other aspects of everyday life. In addition, when employing these problem-solving skills to address basic inquiries, scientists typically create more questions than they answer during a scientific inquiry.

One of the greatest obstacles to implementing *Standards*-based reform and emphasizing "science as process" is that most K-12 educators lack formal training and experience in "doing science" (NSF97-171). This is especially true for elementary (grades K-5) and middle level (grades 6 - 9) teachers who are critical to providing the foundation in the science process skills for our children.
As part of a project at the University of Nebraska-Lincoln (UNL) funded by the Howard Hughes Medical Institute, a course entitled Earth Systems Science for Educators has been specifically designed for elementary and middle level pre-service teachers. The purpose of this paper is to describe the 16 week, one semester course and what we have learned over the last 2_ years.

Goals:

Earth Systems Science for Educators is for students in UNL Teachers College who are intending to be elementary or middle level teachers. By the end of the course, it is our intent that each student will:

- Develop or enhance their science process skills.
- Understand and apply basic earth science concepts.
- Collect and interpret information and data about earth systems.

Philosophy:

Students are introduced to fundamental concepts in the earth sciences and their relationship to the "real world." All the concepts to which students are exposed can be related to both the K-12 National and Nebraska science education standards. We emphasize that this is a science class and not a teaching methods class. Because this class is specifically for perspective teachers, many of the activities that we do can be used directly in an elementary or middle school classroom. However, we expect our students to be learners at a college level. The students are provided opportunities to learn about the earth and challenged as learners to understand and apply basic earth science concepts to their lives. Although we do what we can to help and assist them, we emphasize that they all have the ability to be successful. They just need to choose to do it.

Course Content:

The content information is presented using a hands-on/minds-on approach that enhances the students ability to undertake more inquiry-based activities, such as their final project, by the end of the class. We emphasize that the earth is a system in which "everything is connected to everything else." We teach this class as though it is a terminal class and assume that these students will most likely never take another earth science class. With this approach, we focus on key earth science concepts and science process skills.

The content of the course includes the following topics:

- Matter and Energy in the Earth System
- Earth and Its Planetary Neighbors
- The Earth in 3-Dimensions (Maps)
- Earth's Weather and Climate
- Investigating Rocks and Minerals
- Earth's Dynamic Water System
- Oceans
- Weathering, Soils and Mass Wasting
- Plate Tectonics and the Rock Cycle
- The Earth in 4-Dimensions: Geologic Time

As part of our approach, we collect and use data. To this end, students collect weather data and use the World Wide Web as a source of daily stream flow and precipitation data for Nebraska rivers. For each of these projects, they give group presentations that provide an opportunity for them to share their data, research questions, and interpretations with their classmates. Earthquake data and seismic interpretation are also incorporated into our section on plate tectonics. The culminating activity is a five-page research paper on a topic selected by the student.

Student Assessment:

Grading Scheme -- To assess the student's efforts we use the following grading scheme:

Learning Logs:	25%
Final Project:	20%
Participation:	20%
Unit Quizzes	25%
Data Presentations	10%

Learning Log -- The purpose of the learning log is to assist the student in organizing their ideas and provide them with an opportunity to think about and apply what they have learned. The learning logs have three key components. First, a self and group assessment is conducted to determine what they know and what they would like to know about the particular topic. The second component is their class notes. These notes along with their course packet should provide the student with a comprehensive record of what they did in class. Third, several key concepts or questions in the unit are identified. For each of these the student writes about what they learned about the concept or question. This is then followed by an explanation of the importance of the concept. Ideally the learning log will serve as individual portfolios that these future teachers can use as a teaching resource.

Final Project -- The final project requires the student to collect and interpret data about a community. Although the student develops their own specific hypothesis, the basic theme of their research is to address the question: "Has your earth system changed?" This project requires them to use their science process skills and communicate their results to their instructors in a five page report.

Participation -- This class is highly interactive so part of the grade is based on participation in activities and discussions. On-time attendance is strongly encouraged not only because being late or absent may impact their grade, but because it is common courtesy. Due to the nature of the course, make-up labs are not offered. It is the student's responsibility to get the materials they miss. The participation grade also includes homework assignments.

Unit Quizzes – After the completion of each content unit, a 30 minute open-resource quiz is taken. Quiz questions are designed to apply the students knowledge to a practical problem, issue or situation. Some examples include:

"You are being interviewed to teach elementary science. As part of your interview, you are given two soil samples and asked to explain why they are different. How would you respond?"

"Understanding the changes in matter from a solid, liquid, to a gas are critical to understanding processes that go on in the atmosphere and hydrosphere. Use the concept of density changes and the particulate theory of matter to explaing why convection occurs?"

Data Presentations and Interpretations – To help students develop their inquiry-learning skills, there are two group projects that involve the collection and interpretation of data. The first project involves the collection of weather data using instruments at their homes. The second project involves using data from the World Wide Web on selected rivers in Nebraska. Once the data is collected, each group presents their data and information to the class.

Course Assessment:

At the beginning of each semester, a survey about the attitudes that students have about science was conducted. The results of these attitude assessments have not been made available to us. Individual discussions with students and email responses to formative assessment questions during each semester suggest that although many were not very enthused about science coming into the class, when they completed it they had a much more favorable attitude. Several students said that prior to this class they would not have placed much emphasis on teaching science. By the end of class, they had a better understanding of what science was all about and would incorporate it into their future classroom activities. Some representative student comments include:

"As far as content - wow! I've really learned a lot this semester. The material is new to me and I feel confident I could teach it to students in the future"

"The information that we are going over is presented in a way that I can usually relate to and understand."

"I didn't expect to do so many experiments and projects, which I find very interesting. I have learned a lot of new information and am planning on using it in my classroom."

"I do think these activities are good, it helps us see things through the eyes of the younger students and will aid us when we end up planning our own science classes."

In terms of content knowledge, we used a pre- and post-knowledge assessment. This assessment was based on the content in the National Science Education Standards as well as articles that have been written regarding misconceptions in the earth sciences. The assessment consists of 38 statements. Our initial assessment in the Fall of 1997 was a simple true-false format. The problem with this format is there is a 50 percent chance of getting the correct response by guessing. To eliminate or at least reduce the guessing on the assessment, an "I do not know" category was added for the Spring 1998 semester.

A summary of the pre- and post-assessments for the spring 1998, fall 1998 and spring 1999 semesters are very striking. For the 63 students in these three classes, the average number of correct answers increased by 27 percent from 21 to 30. In the spring semester of 1999, 14 of 24 students had pre-course scores less than 20 having an average of 16. The scores of these students increased by an average of 15 points to 31.

In the pre-course evaluation for all three semesters, 97 percent of the students knew that the scale of a map is used to determine the distance between two points. Most students also knew that the earth's surface has changed since the beginning of time (95 percent). The two questions most often missed were that soils are not deposited as natural rock layers (97 percent) and groundwater occurs as underground river and lakes (94 percent). The concepts that students showed the greatest amount of improvement was in their understanding that Nebraska was once covered by inland seas; the process by which mountains form and earthquakes occur are caused by the same internal processes within the earth; planet earth is 4.6 billion years old; and the primary source for natural resources is rocks and minerals.

Self Assessment:

Based on four semesters of interaction with 87 students having a wide range in backgrounds, we know that pre-service teachers can learn and can do science if given the opportunity. Our pre- and post-test data clearly indicate that these students are improving their content knowledge. We have also learned that a variety of approaches must be used to engage the student. In the context of doing science, each student is capable of collecting data. They also can become proficient at evaluating factors that influence the quality of a data set. The primary difficulty occurs at the point when students have to develop their own questions and then try to address them in a coherent fashion. Although we have provided more time for students to work and get help on their projects in class, many struggle with the concept of coming up with their own answers. This is not surprising because, for most of them, they have never had to come up with a solution for a question for which there was not already an answer.

As an instructor, but more importantly as a scientist, we need to be much more explicit and to take the time to explain the reasons why we do the things the way we do. We cannot assume that others, especially those that have minimal science background, will have or should have the same ability to evaluate scientific information. Instructions and procedures need to be explicit. You cannot assume students know how to do something if they have never experienced it before.

Holding a Poster Session in place of the Final Exam for an Introductory Geology Class

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Just as individual students learn better by different methods (e.g.,visual vs. aural), they have varied strengths in test performance. Some excel at multiple choice or true/false questions, others on essays, still others in oral presentation; but large enrollment general-education classes usually rely on computer-graded short answer tests. To provide an alternative method of assessment in an introductory geology class, I designed a final project that is modeled after the poster sessions at scientific meetings. This project also incorporated both writing and library or Internet research into the class and gave non-science majors a taste of how scientists exchange information. Students in "Geology of the National Parks and Monuments" each prepared a poster about the geology of a park, or other unit under the jurisdiction of the United States National Park Service (NPS). During the regularly scheduled 3-hour final exam time, they displayed their own posters and viewed those produced by classmates.

Each poster was required to 1) describe the age and type of rocks in the park, 2) explain at least one geologic process or feature illustrated by the rocks or the landscape, and 3) give basic information such as location and year of incorporation into NPS. In addition, they could include information about wildlife, ecology, archeology, recreational opportunities, etc, found at the park. Students filled out a brief evaluation form after finishing their reviews. Comments on preparing individual posters were mostly positive (creative, fun, interesting), although a few were negative (time consuming, childish, expensive).

Comments on the poster reviews completed during the display time were mixed, expressing frustration (crowded rooms, small fonts, incomplete posters) as well as appreciation (beautiful pictures, variety of parks, artistic exhibits). Out of a class of 110, only five would have preferred a written final exam.

During the final time, I and a team of five teaching assistants evaluated all posters, rating them on a scale of 1 to 4 in categories such as rock description, use of maps and pictures, organization, and legibility. Although there were not enough judges to have two people look at every poster, a few overlapping evaluations matched to within 1/2 point. Thus this method, though somewhat subjective, appears to be reliable. The mean score on the project was about 10% higher than the means for lecture exams and lab quizzes given in class during the semester, but the distribution of project scores was comparable to the distribution of scores on the written tests. This suggests that the grading criteria were more lenient for the project than for the tests -- a point that should be addressed in the future. Because the overall response was positive and the project accomplished the goals I had set for it, I plan to use the same format again.

New Curriculum Reform of Science Education in Korea in 2000

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Introduction

After the Republic of Korea was founded in 1948, the Korean modern education system was rapidly changed from the traditional system. As Yi (1997) observed, the Educational Law legislated and promulgated in 1949 reformed Korean education into a national, publicly funded, single-track school system. Emphasizing national identity and the idea of *hogik ingan* (meaning, 'being of benefit to all of humankind'), the Education Law prescribes the ideals and goals of education and stipulates principles and criteria that guide the administration and management of the educational system (p. 42). Remarkable economic growth and changes in politics, society, and culture have continuously brought about a quantitative expansion and qualitative development of Korean education . For example, a report of the Third International Mathematics and Science Study (TIMMS), conducted in 1995, showed a relatively excellent educational system in Korea.

"In mathematics, fourth-grade students in 7 countries outperform our fourth graders (Singapore, Korea, Japan, Hong Kong, the Netherlands, the Czech Republic, and Austria). ... In science, students in only one country-Korea-outperform U.S. fourth graders. Student performance in 5 countries is not significantly different from ours (Japan, Austria, Australia, the Netherlands, and the Czech Republic), ..." (U.S. Department of Education, 1997, p. 19).

This paper presents a brief outline of the Korean educational system, a brief history of national curriculum, and new national curriculum and reform based on science education.

Educational System

Korea has a centralized educational system controlled by the Ministry of Education (MOE). Local offices of education at 15 districts (9 provinces and 6 metropolitan areas) are mainly controlled by the MOE. In other words, all schools in Korea are supervised and controlled by their local offices of education and the MOE. The current school system has been a single track of six years in elementary school, three years in middle school, three years in high school, and four years in university since 1949 (MOE, 1997c, 1998a). However, this ladder-type 6-3-3-4 pattern will be changed to 12-4 pattern (1^{st} –12^{th} grades) in 2000. It is one of remarkable educational reforms in new 7^{th} national curriculum (MOE, 1999).

National Curriculum: Change And Reform

The MOE has "the power to lay out national standards and contents of curriculum, but the school superintendents may establish further standards and contents to reflect their districts' particular situations. This is to be done within the limits of the curriculum set by the Minister" (MOE, 1998a, p. 11). Therefore, all schools' curriculum contents and time allocation are uniform with a few variations depending on the regional and local situations.

Table 1 shows a brief history of national curriculum change, and characteristics. There have been seven revisions of the national curriculum since 1948. Each revised national curriculum was strongly influenced by educational trends and issues. These national curricula are revised every 5 to 10 years to cope with new educational needs, socio-economic demands, national transitions, and academic advancement. Although the current 6^{th} revised curriculum, focused on humanistic curriculum, was only just implemented in 1995, a new 7^{th} revised curriculum will gradually come into effect for all grades from March 2000 through March 2004 (MOE, 1999).

The 7^{th} revised curriculum focuses on "individual human development with more specific goals that include: 1) reaching the full potential of one's character, 2) exhibiting applied abilities based on basic capabilities, 3) comprehensively cultivating one's path, 4) creating new values based on the understanding of Korean culture, and 5) dedicating oneself to civic duty for a democratic community." (MOE, 1998a, p. 12)
This new curriculum comprises the National Common Basic Curriculum (NCBC) for grades 1 to 10, and the High School Elective-Centered Curriculum (HECC) for grades 11 through 12. This

structure of the new curriculum is one of the big differences between the 7th and the previous curriculum. As can be seen in Table 2, NCBC consists of subject matters, optional activities and extracurricular activities. The subject matters are divided into ten subject areas: Korean Language, Moral Education, Social Studies, Mathematics, Science, Practical Arts (Technology, Home Economics), Physical Education, Music, Fine Arts, and Foreign Language (English). However, subject matters for grades 1 and 2 are integrated in Korean Language, Mathematics, Disciplined Life, Intelligent Life, Pleasant Life and We Are the First Graders. In addition, optional activities are divided into subject matter optional activities and creative optional activities. Extracurricular activities are composed of student government activities, adaptive activities, self-development activities, social-service activities, and event activities.

On the other hand, HECC consists of subject matters and extracurricular activities, but not optional activities. The subject matters are divided into general subjects and specialized subjects. The general subjects for grades 11 and 12 are subdivided into general elective course and intensive elective courses. For example, there is "Life and science" as a subject for the general elective course of science. Intensive elective courses for science include "Physics I, Chemistry I, Biology I, Earth Science I, Physics II, Chemistry II, Biology II, Earth Science II." As mentioned above, this new curriculum, considered as the student-centered curriculum, will provide a variety of elective subjects for students according to their interests and levels.

Reform of Science Education

Science education as a general compulsory and core subject has been offered to all grade students since 1948. The goals of science in the 7th revised curriculum are to help students to (a) understand scientific knowledge and apply it to their real life through inquiry-based learning, (b) foster scientific inquiry-based abilities in order to apply them to real life, (c) foster scientific attitudes to solve real life problems based on scientific interests and curiosities, and (d) understand the influence of science on the development of technology and society (MOE, 1997b). Recent science education goals reflect an increased emphasis on scientific knowledge and inquiry-based abilities as a component of scientific literacy.
One of reformed components of new curriculum is that NCBC will be organized and implemented as two types of differentiated curricula. The first type, *Symhwa bochung hyeong kyoyuk kwachong* (literally, 'in-depth and supplementary differentiated curriculum') shall be offered from grades 3 through 10 for science subjects (MOE, 1997b). According to science contents, students can be subdivided into the following three levels: Lower level (grades 3 to 5), Middle level (grades 6 to 7), and Upper level (grades 8 to 10). These patterns will contribute to removing level-discrepancies of the former 6-3-3-4 pattern and to maintaining the close connection between grades. The second type, *Suzunbyul kyoyuk kwachong* (literally, 'level-differentiated curriculum') shall be used for mathematics. Ten levels of mathematics courses shall be offered from grades 1 through 10 (MOE, 1997a). It is expected that this science curriculum will outperform previous curricula in different areas of science at all age levels.
The other reformed components are that the major focus of science contents will be changed from phenomena and activities-based contents to conception-centered as grades increase (see Table 3). In the structure of contents, this curriculum is divided into 'Knowledge section' and 'Inquiry section'. The former section is composed of four main themes: Motion and Energy, Matter, Life, and Earth. This section is organized to make close connections between grades. The latter section consists of three areas: 'basic inquiry', 'integrated inquiry', and 'inquiry-based learning activity'. This section emphasizes gradual developments of inquiry-based abilities.

Discussion

The purpose of this paper was to introduce the new 7th national curriculum in Korea and to present the major reformed components of science education. As mentioned before, the Korean national curricula have been reformed in 5-10 year cycles seven times since 1948. The 7th revised curriculum will be implemented in 2000 and will fundamentally change the structure of the Korean educational system. As Kim and Land (1994) described in the summary section, science education in Korea has had some problems including a lack of fundamental curriculum research, preservice and inservice programs for science teachers, a lack of instructional materials and facilities for science activities, and so on. It is hoped that this educational reform will solve current education problems and will contribute to the development of Korean education in the 21st century.

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Table 1. Brief history and characteristics of national curriculum changes

Revision	Period of Curriculum	Characteristics
1st	1955 – 1963	Subject-centered curriculum
2nd	1963 – 1973	Experience-centered curriculum
3rd	1973 – 1981	Discipline-centered curriculum
4th	1981 – 1987	Humanistic curriculum
5th	1987 – 1995	Humanistic curriculum
6th	1995 – Present	Humanistic curriculum
7th	2,000 – ?	Student-centered curriculum

(Modified from MOE, 1998b, p. 12)

Table 3. General comparison of instructional hour per week and unit between 7th and 6th national curriculum (modified from KNUE, 1997, p. 17)

<table>
<tr><th colspan="2">Grade</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th><th></th><th>11</th><th>12</th></tr>
<tr><td rowspan="3">Clas s hour/ week</td><td rowspan="2">7th</td><td>3</td><td>3</td><td>3</td><td>3</td><td>3</td><td>4</td><td>4</td><td>3</td><td rowspan="3">Subject (unit)</td><td colspan="2" rowspan="2"># General elective course
Life and science (4)
Intensive elective courses
Physics I (4), Chemistry I (4),
Biology I (4), Earth Science I (4)
Physics II (6), Chemistry II (6),
Biology II (6), Earth Science II (6)</td></tr>
<tr><td colspan="3">Contents focus on natural phenomena (NR)</td><td colspan="2">NR & Con-cep-tions (C)</td><td colspan="3">NR & Conceptions</td></tr>
<tr><td>6th</td><td>3</td><td>4</td><td>4</td><td>4</td><td>4</td><td>4</td><td>4</td><td>4</td><td colspan="2">Physics I (4), Chemistry I (4),
Biology I (4), Earth Science I (4)
Physics II (8), Chemistry II (8),
Biology II (8), Earth Science II (8)</td></tr>
</table>

The figures in parentheses are the number of units to be completed, and one unit means the amount of school learning undertaken by a 50 minute instruction period per week for one semester, which is equivalent to 17 weeks.

Table 2. The National Common Basic Curriculum in Korea (MOE, 1999, p. 17)

Schools & Grades / Subjects		Elementary School						Middle School			High School		
		1	2	3	4	5	6	7	8	9	10	11	12
Subject Areas	Korean Language	Korean Language 210	238	238	204	204	204	170	136	136	136	Elective Courses	
	Moral Education	Disciplined Life 68		34	34	34	34	68	68	34	34		
	Social Studies			102	102	102	102	102	102	136	170 (Korean History 68)		
	Mathemat-ics	Mathematics 120	136	136	136	136	136	136	136	102	136		
	Science			**102**	**102**	**102**	**102**	**102**	**136**	**136**	**102**		
	Practical Arts	Intelligent Life 90	102	-	-	68	68	Technology & Home Economics 68	102	102	102		
	Physical Education	Pleasant Life 180	204	102	102	102	102	102	102	68	68		
	Music			68	68	68	68	68	34	34	34		
	Fine Arts			68	68	68	68	34	34	68	34		
	Foreign Languages (English)	We are the first graders 80	-	34	34	68	68	102	102	136	136		
Optional Activities		60	68	68	68	68	68	136	136	136	204		
Extracurricular Activities		30	34	34	68	68	68	68	68	68	68	8 units	
Grand Total		830	850	986	986	1,088	1,088	1,156	1,156	1,156	1,224	144 units	

1) The above table shows the minimum numbers of total annual instructional hours by subject and grade level (grade 1 through 10) during 34 school weeks a year for the period of the national common basic education.
2) For grade 1, the standard number of school weeks assigned to subject matters, optional and extracurricular activities is 30. The number of instructional hours allocated to 'We Are the First Graders' represents the number of instructional hours in March.
3) In principle, one instructional hour covers 40 minutes for 1st to 6th grades, 45 minutes for 7th to 9th grades and 50 minutes for 10th to 12th grades. However, the school is entitled to adjust the duration of each instructional hour depending on the weather and seasonal changes, individual school situations, the developmental level of the students, the nature of learning, and so forth.
4) The numbers in the cells of extracurricular activities and the annual grand total rows for the grades 11 and 12 columns represent the number of units to be completed for those two years.

Earth System Science and Global Change Education Workshops: Building International Partnerships

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The Inter-American Institute for Global Change Research (IAI) is an international cooperative effort among 19 countries in the Americas seeking to improve understanding of global change. IAI member universities and the Universities Space Research Association (USRA) recently offered a series of Earth system science and global change education workshops supported by the IAI Initial Science Program – III. Aims of the workshops were: 1) to develop among IAI member faculty an integrated view of the Earth system as it underlies the IAI science themes, 2) to build a collaborative infrastructure for IAI participants sharing common needs in education and training and 3) to provide for early implementation of interdisciplinary courses in Earth system science and global change.

Two 12-day workshops, each for 20 participants, were held - one by the Universidad Autónoma de Baja California (UABC) in Ensenada, BC, México in September, 1998 and the other by the Fundação Universidade do Rio Grande (FURG) in Rio Grande, RS, Brazil in April, 1999. Interdisciplinary university teams came together to learn about Earth system science and global change topics in the context of the IAI science themes as focused by the coastal studies expertise of both institutions. Participants identified and shared resources for developing courses and classroom materials. A third workshop to be scheduled in 2000 will invite participants from the first two workshops and others to share the results of their collaborative efforts and to plan for a broader system-wide education effort involving all member countries and IAI science themes.

Workshop participants are members of a networked e-mail list server to facilitate collaboration and interaction beyond the workshop as they develop resources at their home institutions, forming a virtual IAI education and training community. An Internet-based collection of links and relevant learning resources (e.g. lesson plans, images, software packages, multimedia exercises etc.) will be routinely updated with IAI-relevant scientific and educational developments. See http://www.usra.edu/iai/iai.html for more information.

The workshops and IAI Education and Training web site will serve the entire IAI membership and build upon existing programs at institutions in Argentina, Brazil, Canada, Costa Rica, Mexico and Uruguay. USRA's ongoing Earth System Science Education Program (ESSE) in the United States is a partner in this effort for the establishment of an expanded cooperative university based education program within the IAI member countries. The early development of interdisciplinary courses and a supporting infrastructure for IAI educators will ensure offering of Earth system science and global change courses for university students pursuing careers outside of science - in law, politics, medicine, economics, etc. Wise policy and environmental stewardship decisions in the future demand an informed society to address the challenges posed by sustainability.

Student Portfolios in Earth Science Education

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Student portfolios are an effective method of assessing student learning in earth science classes. A portfolio is a thoughtful collection of journal and magazine articles about the latest research and discoveries in the earth sciences. Students must collect these articles in the library and over the internet. Each article must be summarized in the student's own words. Articles must have been published within the past two years and the author's credentials should be identified. A bibliography must be submitted.

Students may also take a personal field trip to a geological site, such as Craters of the Moon National Monument or Yellowstone National Park. They should collect written information and speak with Park Rangers, then report on their personal discoveries. Some may choose to visit a virtual field trip web site and report on their findings.

A final evaluation of learning is summarized by each student by:

- writing about any personal or educational goals achieved in completing the portfolio,
- estimating the amount of time spent working on their portfolio,citing the most useful of the resources they used,
- choosing an article which they favored, giving a reason for that choice, and
- submitting a self evaluation assessing the outcome of their educational experience in completing the portfolio.

Students must be self motivated to finish a major project of this type, and the outcome is frequently a voyage of individual discovery. Good students begin to realize that learning about science on their own, without teacher guidance, is personally challenging and fulfilling. Many state that science is a subject they had previously hated, but now really like. They express a desire to become life-long science learners. Students report that completing the portfolio is a positive educational experience.

Anecdotal evidence collected over the past five years of student's achievement of goals will be included. Actual portfolios will be displayed. The author's grading rubric will be available. Directions for completing a portfolio is given to students in the syllabus, a copy of which will be available.

Teaching Fundamentals Of Spatial Data And Geographic Information Systems Without Lecturing: Design and evaluation of a teaching approach using a digital tutor and simulation exercises

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Introduction:

This presentation summarizes an initiative to teach students without lectures or structured laboratory exercises. The course material deals with introductory level knowledge. The course objectives are to introduce students to fundamentals of spatial data and to give students sufficient computer literacy to use and understand a geographic information system (GIS) package called Arc Info by ESRI in a UNIX computing environment.

The first part of the presentation introduces curriculum content and explains the post-secondary institutional environment and thinking that led to this pedagogic initiative. The second part of the presentation summarizes previous digital courseware we designed that led us to this initiative, as well as introducing design and format of the curriculum and its delivery mechanism. The third part reports on our experience offering this course for the first time in the first semester of 1999.

Part 1: Background

A number of factors led to the search for an alternative approach to teaching two regular courses on spatial data and GIS. They are:

1. excessive wait lists to get into the two courses;
2. the course requirements of a new joint undergraduate program between Earth and Ocean Sciences and Geography;
3. the recognition of a growing life-long learning and adult education market; and
4. pedagogic curiosity.

The School for Earth and Ocean Sciences and the Department of Geography at the University of Victoria have formed a joint undergraduate major that focuses on preparation of students for professional earth science certification. The joint program requires students to take a number of core courses in geographical techniques offered by the Department of Geography, including a 2nd year course dealing with *"Fundamentals of Geographical Information"* (Geog 202) and a 3rd year course covering *"Introduction to Geographical Information Systems"*. Both courses have ceilings imposed by laboratory program capacity limits and, in the case of Geog 202, there also is a limit imposed by the size of the lecture theater. Both courses are over-subscribed with sometimes twice as many students on the waiting list as can be accommodated. The challenges are to meet existing demand and accommodate additional demand imposed by the new joint program.

The 2nd year course covers fundamentals of spatial data in three parts. The 1st part of the course deals with understanding spatial data and their collection. Students are exposed to fundamental concepts including datum, map projections, scale and geo-referencing strategies. Students also learn about classification of spatial data and associated attribute data, as well as spatial sampling. Data collection by ground surveying, remote sensing and secondary data gathering are introduced. The 2nd part of the course focuses on the organization and basic description of the data. Students learn about data encoding, descriptive parametric and non-parametric statistics, and basic hypothesis statements. The 3rd part of the course focuses on communication. Students are challenged to think about organizing information for effective communication. Basic thematic and topographic cartographic design concepts are introduced. The course finishes with lectures on evaluation of data quality and data management issues. The course consists of 36 one hour lectures and 11 two hour laboratory exercises offered over an 11 to 12 week period. Some of the laboratory exercises require access to a Pentium computer laboratory. All Geography majors are required to take this course. More detail can be found in Keller 1995 and 1996.

The 3rd year course introducing GIS follows a similar tripartite division to the 2nd year course. The course is designed around an 11 exercise laboratory program taught with the aid of a digital on-line tutor (Keller et al., 1995, 1996). The laboratory program requires students to access ESRI's ArcInfo in the Department of Geography's ten workstation UNIX lab. Students have access to the digital tutor at all times. Each student also is scheduled to have a three hour period per week shared with nine other students in the laboratory when a teaching assistant is available. Exercises are handed in at the end of each week. The 11 exercises take students sequentially through database design and data specifications, digitizing, topology building, data attribution, cartographic measurements and spatial query, visual and topological overlay, buffering, building of a terrain model and associated slope and aspect model, intervisibility analysis, network analysis, and cartographic output. Lecture material covers the theoretical foundation for the laboratory exercises and discusses ongoing research in each area. There are two lectures per week over an 11 to 12 week period. At the end of the year, students must pass a three hour laboratory examination as well as a two hour written theory examination.

Both courses are popular and every year, student demand for these courses exceeds supply capacity. The introductory 2nd year course is offered in both of the teaching semesters and often has to be offered a 3rd time during summer session to meet incoming student requirements. Undergraduate students have had to delay graduation for one or two years to get into the 3rd year GIS course. Irate parents have called the president's office to complain and our students have staged a positive protest by collecting a can of food for every waitlisted Geography student (over 1000) which they presented to the university's senior administration for donation to the local foodbank. Administration, in response, are exerting pressure to change the requirements or method of delivery of these courses better to manage demand. The Department has responded in a number of ways. We developed the digital tutor for the GIS course (Keller et al. 1995, 1996), and thereby were able to increase lab sizes and number of lab sessions. We also have simplified some lab exercises, although reluctantly. Search for marginal increase in capacity here and there has not solved the overall capacity problem.

An obvious solution in the short-term is to re-design the requirements for these two courses to facilitate servicing more students with the same supply of faculty, teaching assistants and infrastructure. We oppose this option based on the firm belief that quality of education should not be compromised by the needs of mass education. Our belief is confirmed by students' evaluations of and feedback on the courses which are very positive, recognizing the important contribution the courses make to their program of study and subsequent careers. Looking for alternatives, we have proposed to senior administration to explore delivery of the material by on-line courseware in an attempt to work around infrastructure constraints. Funding for this experiment was secured from a government grant and senior administration.

Part 2: Curriculum Design and Delivery Mechanism

We gained knowledge and familiarity with web based teaching software while designing the digital tutor for the 3rd year GIS course (Keller et al. 1995, 1996). We moved on to develop an on-line distance education version of the lecture component of the 2nd year course. This course was offered on-line during the Spring of 1997. The course was evaluated through submission of ongoing comments by students via electronic mail, through regular end-of-term evaluations, and through a face-to-face meeting with the class after the final examination (where we saw the students for the first time). We summarized our learning experience designing and writing the courseware in a nine page report to senior administration. The report commented on the considerable technical expertise and time required to undertake this type of courseware development. The report also identified a number of bottlenecks with respect to university computing and network access that created course delivery problems. The report concluded by making recommendations with respect to university infrastructure and support that would help other faculty develop on-line courseware. We learned from students that they liked what we did, but that they had some reservations. Students rated very highly how we organized and delivered the course material. They enjoyed the freedom to access the course notes in their own time and from their residence. They critiqued the absence of laboratory exercises to supplement the lecture notes, and they commented on the desire to interact with other students beyond e-mail and a class chat-line in order to gauge their progress and to be re-assured that they were "on track".

Based on experience gained, we secured support to develop an on-line version of the 3rd year GIS course that would incorporate the foundation lecture material from the 2nd year course and the tutor. The goal was to develop a stand alone course that could be taken by students on-line as a year long course, combining the 2nd and 3rd year course materials. Given what we learned from previous courseware developments, we decided to incorporate laboratory exercises as part of the course material, including methods for self-evaluating progress. For example in the lecture notes on data entry, students encounter a section that gives detailed instructions on how to digitize maps, including images showing what the final digital database should look like. Dispersed throughout the courseware are numerous questions whose answers can be obtained by moving the mouse over an answer box. The courseware took 18 months to develop. The course was tested on 22 students during the Spring of 1999. The course consists of:

1. no structured lectures - the focus is on independent learning of core concepts and information processing practices using a hypertext document called the *"Ptolemy Notes"*;
2. no structured labs - students can drop in and complete exercises mentioned in the "Ptolemy Notes" anytime - (the lab is accessible 24 hours/day) - we also set times aside when the lab was dedicated to this course and when TA help was made available;
3. opportunity to participate in weekly structured drop-in tutorial sessions to address unresolved or poorly explained concepts and to answer questions; and
4. the requirement to participate in two simulation exercises to gain real-world experience and apply material learned (each simulation required students to have advanced to a specified stage in the course materials and laboratory exercises).

Students were evaluated as follows: participation in simulation exercises (20%) ; mid term progress evaluation (15%); final laboratory examination (20%); and final examination (45%). The oral presentation offered in conjunction with this abstract will show-case the Ptolemy Notes.

Part 3: Evaluation and Review

The new on-line course (# of students = 22) was run in parallel with a regular section of the 3rd year GIS course (# of students = 40). Students from both courses were given the same quiz and *"Learning Style"* exercise (McBer and Company, no date) at the beginning of the courses to allow for class comparison. Students in the regular 3rd year course performed marginally better in the opening quiz reflecting that they all had the 2nd year course as a pre-requisite. Some of the on-line students did not have this pre-requisite. Both classes received the same final laboratory and theory examinations. There was no statistically significant difference in the performance between the two classes in either of the two examinations at the end of the year. However, students did comment on the differences in learning experience and students in the on-line course commented on the excessive workload (not surprising given that they were asked to cover the material prepared for a 3 unit two term course in a 1.5 unit single term course) .
The oral presentation associated with this abstract will offer highlights of our efforts to develop this course, our experience teaching with it, and additional insights into what the students told us in their course evaluations and during an informal de-briefing meeting.

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UK Staff Development in the Earth Sciences: an update.

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At GeoSciEd II, I presented a poster describing the outcomes of the first year of the UK Earth Science Staff Development project. The funding for the project finishes in November 1999, this presentation will describe the overall outcomes and evaluation of the project and will briefly outline the future of discipline-based learning and teaching initiatives in the UK.

In 1996, funding was acquired from the Higher Education Funding Council for England (HEFCE)'s Fund for the Development of Learning and teaching (FDTL) to resource a series of national, discipline-specific staff development workshops for Earth Sciences academics. This project was developed as a sister to the Department for Education and Employment (DfEE) funded UK Earth Science Personal and Career Development Network which focused on developing students.

Details of the past and forthcoming workshops, together with a catalogue of case studies of good practice in Earth Sciences learning and teaching can be found at the website:
http://www.soton.ac.uk/~ukgec/

The staff development project has now completed it's final year of funding and has been extremely successful in its aims

- to identify current best practice in Earth Sciences learning and teaching and to promote its widest possible dissemination, take-up and implementation;
- to promote wider awareness amongst Earth Sciences educators of national and international initiatives in educational developments and
- to provide a forum for the discussion and exchange of ideas in learning and teaching practice.

The workshops were very well received and attendance averaged around 20 - our considered optimum for such, interactive events. Various issues were addressed at the different events including effective use of the Internet for learning and teaching, computer-based assessment, teaching large classes, teamworking, good practice in learning and teaching in fieldwork and Key Skills.

Over the lifetime of the project there has been a perceptible change in the attitude of participants towards developing their learning and teaching practice. In general, individuals and departments now seem more willing to *share* ideas and innovations in order to prevent 'reinvention of the wheel' and are moving away from the 'not invented here' syndrome. .

The future of discipline-specific staff development: at the time of writing the project has submitted a bid to the FDTL for a further 8 months funding. Part of this funding is to cover the production of an Earth Sciences Continuing Professional Development (CPD) resource pack based on the material gathered via the workshops.

Additionally, the project has applied for funding in collaboration with projects in Geography and Environmental Sciences to provide a national, residential workshop for new lecturers and to collate, combine and disseminate the products of the projects across the three disciplines.

This work will be continued by the Geography, Earth and Environmental Sciences Subject Network which is due to be launched early in 2000.

[NB: at the time of writing, June 1999, we are awaiting the outcome of various bidding processes for further FDTL funding and for the establishment of the Subject Network. Full details will be available by January 2000]

Digital teaching material for geological applications of GIS

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Knowledge in the Geosciences is essentially spatial. In Geology, Geography, Geophysics, Geochemistry, and other branches of Geoscience, a numeric information has no sense if it is not associated to a spatial information. Only in the eighties the increase of capacity of microcomputers and of input and output devices allowed computer processing of graphic data and presentation of results at costs compatible with other phases of work in Geosciences. Geographic Information Systems (GIS) where then developed, which make possible the treatment of spatial data using techniques of several origins, like Database Management, Computer Mapping, Statistics, Geostatistics, Image Processing and Surface and Volume Modeling.

The Geological Computing Laboratory (LIG) of the Department of Sedimentary and Environmental Geology of the Institute of Geosciences of the University of São Paulo, Brazil, develops research and application projects in the areas of GIS, Remote Sensing, Mineral Deposit Modeling, Geophysics and Hydrogeology since 1990. The GIS group accumulated experiences, data and results of applications for Geology, Mining and Environmental Management areas as diverse as the São Paulo Metropolitan Area (18 million people in 3.000 km^2 of urbanized area) and the Amazon. These experiences are used as teaching material in GIS and Remote Sensing courses and in Geoscience courses not directly linked to GIS, such as "Environmental Geology", "Planning Geology ", "Mining and the environment" and "Earth Resources" The experience in these non-GIS courses was reported in Macedo (1998).

The Integrated System of Support to Teaching (SIAE), maintained by the Pro-Rectories of Undergraduate and Graduate studies of the University of São Paulo, has established the Program of Incentive to Production of Teaching Materials, to finance activities of teaching renewal in the University. The Digital Teaching Material for GIS Applications project was proposed by the author and executed with the participation of faculty and students working at the LIG. Its objectives are the production of digital teaching materials to be used in formal and informal courses, for the teaching of GIS functions and abilities as well as of Geoscience issues. The exercises can be more directly applied for students of undergraduate and graduate courses in Geology and Geography, but they can be used for students of Geosciences and GIS applications of any origin.

In the first phase of the project exercises and support texts were written and presented in CD-ROM. In the second phase, now in process, a selective distribution and test of the exercises is being made. In the third phase the exercises will be disseminated by the Internet, at the LIG page (*http://geolig.igc.usp.br*).

GIS functions

The Geographic Information Systems perform the following functions, as defined by Bonham-Carter (1994) and Eastman et alii (1995), which will be developed through the exercises:

Organization: data are organized, after collection and conversion to the digital format, making a database joining spatial and non-spatial data (attributes).

Visualization: maps, tables and texts are visualized on screen, or as hardcopy, made by printers and plotters.

Spatial Query: queries to the database allow to obtain, in graphic or table format, information such as: location of geochemical anomalies, location of mineral occurrences classified by size, location of occurrences to a given distance of a structural lineament, etc.

Combination: spatial and attribute data of several sources are merged, allowing to join the remote sensing images with maps, for example, making cartographic modeling.

Analysis: is the process of inferring meaning from the data, by spatial and non-spatial techniques. Classic and spatial statistics, geostatistics, map overlay and trend surface analysis are some of the techniques used to make synthetic maps used for understanding geoscientific phenomena.

Prediction: the next step is the application of the space analysis for prediction, in cases such as the determination of potential areas for mineral resources exploration or the favourability of tracts of land for different uses.

Decision support: the favourability analyses may be supported by comparison between possible uses, using Multi-objective and Multi-criteria techniques (Eastman et alii, 1995). An important decision problem studied in the exercises is the choice of allocation of a certain area for mining, environmental preservation or agriculture.

Cartographic production: scale adjustment, legend production and drawing of graphic patterns, production of basic or derived maps, with graphic quality adapted to the objectives of the project.

Exercises

The exercises were written aiming at developing GIS abilities and Geoscience knowledge. The data used as examples are always real, produced by projects developed at the Institute of Geosciences-USP or the Brazilian Geological Survey, coordinated by the author. Data are supplied in two formats:
- in IDRISI format: vector files (.VEC) and raster files (.IMG) that can be also directly processed by the Catalan program MiraMon.
- in .DXF vector format and .BMP raster format, with georreferencing information in .DOC ASCII files, that can be used by almost any program, as they are de facto standards for spatial data.

The operational instructions for the exercises are directed to IDRISI users, and they assume a basic knowledge of the program. Users of other systems can easily adapt them to their specific programs.

The IDRISI GIS is produced by the Clarklabs, of Clark University, Worcester, Mass., USA. The best reference source on the program, as well as of demos and interactive tutorials is its Internet page, with address: *http://www.clarklabs.org*. Files in IDRISI format can also be directly processed by the MiraMon program, with demo and tutorials at the page *http://www.creaf.uab.es/MIRAMON*.

Description of the exercises:

1 - Perau mine
Data: raster maps: geology, vegetation, deforested areas, pollution sources; vectors: inhabited areas, drainage, roads, mining works.
GIS: visualization of raster and vector images; use of Digital Elevation Models; slope and area calculation.
Application: in Mining and Environment: study of environmental impacts and planning of reclamation for areas degraded by mining.

2 - Ilhabela:
Data: contour lines and location map.
GIS: calculation and visualization of Digital Elevation Model and its derivations: slope and aspect maps.
Application: land use and environmental conservation planning.

3 – Pariqüera-Açu:
Data: raster maps: geologic, present land uses, vegetation, urbanized areas; vectors: contour lines, drainage, roads.
GIS: calculation and application of DEMs, analysis in one map and combination of maps to make derived maps and determine favourability for several land uses.
Application: construction of geotechnical and risk maps, determination of possible land uses for Rural and Urban Planning.

4 - Paqueiro mine:
Data: raster maps: geologic, topographic, soil geochemistry, mineral deposits and occurrences; vectors: sampling points and Cu, Pb and Zn concentrations.
GIS: analysis in one map (statistical calculations, reclassification) and map combination by Boolean and index methods.
Application: integration and interpretation of data for mineral exploration in mine scale (1:5.000).

5 - Iporanga:
Data: Landsat satellite images (6 bands), raster maps: geologic, geochemical, DEM.
GIS: image processing for geological applications, combination of maps with satellite images and DEMs, vegetation index calculations, 3D visualization.
Application: integration of data for geologic mapping, mineral exploration and environmental

analysis: determination of areas suitable for mining, agriculture and environmental preservation, in semi-detailed scale (1:50.000).

6 - Ribeira River Valley:
Data: Maps, vectors and tables with geological, geochemical (Cu, Pb and Zn concentrations in stream sediments), environmental protection areas, DEM.
GIS: analysis in one map (statistical calculations, reclassification, trend surface analysis), construction of factor maps, map combination, decision support techniques.
Application: integration of data for Regional Metallogenic analysis (1:100.000 scale).

Results:

In this pilot phase, the exercises are being tested with students of Geoscience courses ("Environmental Geology", "Planning Geology ", "Mining and the environment", "Earth Resources" "Mineral Exploration" and "Mineral Deposit Modeling") and of courses on GIS applications in Geology and Environmental Studies.

With the feedback from these tests, the exercises are being modified to improve its intelligibility and the exploration of the applications. New exercises are being written using data from recently finished projects.

The exercises are being well received by teachers and students, allowing improving the understanding of the studied Geoscientific subjects and making the students able to develop research and application projects using GIS.

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A Handmade Seismograph System and its Seismograms -Make Your Own Seismograph!-

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Preface

The seismograph is a fundamental instrument in geoscience. However, the seismometers that can record natural earthquakes are developed very few (e.g. Waker, 1979) for the use in school as a teaching tool. This is quite different from the other field of science such as astronomy or meteorology, where instruments for school use are common. In this regards, since the first prototype of our seismograph system in 1989, we have developed and improved the system for easy operation and more precise seismic observation at school or home (Okamoto, 1991). Now, our system can detect local earthquakes of M>2 within 50km and foreign earthquakes of M>7 elsewhere (M: magnitude) scale). In this paper, we describe the details of our seismograph system, example of seismograms, and summary of our new simplified sensor which is easy to make at low-cost.

Seismometer and related devices

Our system consist of three parts (Fig.1):
i) Seismometer (sensor), ii) Amplifier + A/D converter + I/O interface circuit, and iii) Personal computer (data logger). A software for auto logging is also required. Three seismometers were made, one is a vertical type, and others are horizontal type.
<Seismometer (Fig.2)>
electro-magnetic sensor + pendulum. Steel body and pendulum with brass mass is used for both vertical and horizontal seismometers. But the pendulum design is quite different between two type. The vertical pendulum is designed for the modified "Ewing type" using a steel coil spring, which has 3sec free period, on the other hand the horizontal type is designed for the "Paschwitz type" which has 5sec free period. Both types employ a magnet removed from a speaker and a wounded coil on a acrylic pipe as a electro-magnetic sensor. To avoid friction, a thin bronze sheet is used instead of a pivot of the pendulum.
<Built in amplifier>
Two types of IC based amplifier are also built in the seismometer. One is a broad band amplifier for local earthquakes, and the other is a low-pass amplifier having cut off of 20 sec for the detection of foreign earthquakes (after Daniel, 1979).

1. **PC based auto logging system**

Automatic logging (recording) system is

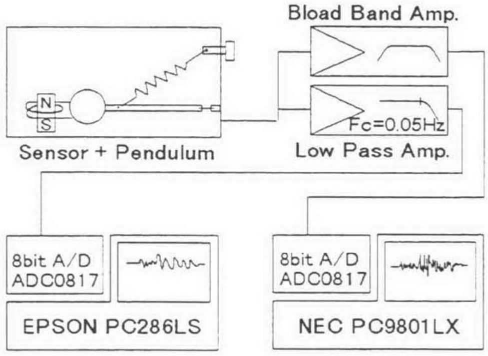

Fig.1 Block diagram of our system.

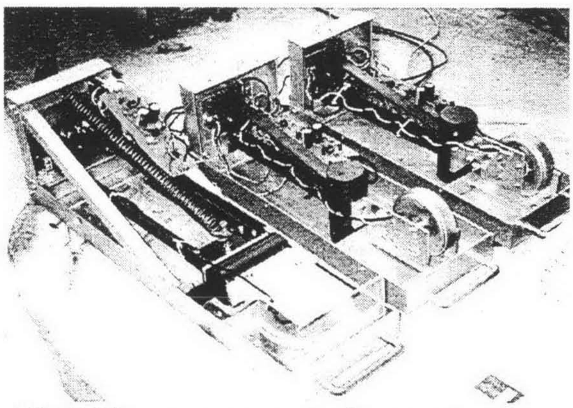

Fig.2 Three component seismometers

desirable for the daily observation of earthquakes. Many logging systems are considered up to now. The old-fashioned seismometer employs a smoked paper on a clock-driving drum. Nowadays, the digital computer changes the recording system dramatically. So our system employs the PC for both control of A/D circuit and auto logging.

<A/D converter>

16-ch 8-bit A/D converter ADC0817 is employed (only 3-ch are now using).

<I/O interface>

Parallel interface IC 8255 is employed. Both A/D converter and I/O interface are built in an extensional board for NEC-PC with a programmable timer IC 8253.

<Software>

The driving software is written in BASIC language for the NEC-PC (Japanese domestic PC). The main function is as follows,

i) 1-ch signal display on CRT at real time.
ii) Auto detection of events with arbitrary trigger level.
iii) Auto save of the signal in the hard disk.

_ Because the saved data are not only of earthquakes but also of traffic noises etc., the selection of natural earthquake data is need. This process is suitable for the routine work in school. Fig.3 shows an example of signal on CRT.

Fig.3 An aftershock of 1995 Kobe earthquake displayed on CRT (time mark interval is 1 [sec] , traffic noises are seen at later)

Seismograms of local earthquakes

Since the first trial in 1989, more than 5000 earthquakes are recorded with previous system at our house in Hashimoto city, Wakayama prefecture (Western Japan). Especially, aftershocks of the 1995 Kobe earthquake has been recorded throughout day and night, because the distance between our observation site and the focus region is only about 60km. Fig.4 shows some examples of local earthquake seismograms.

Seismograms of foreign earthquakes

Detected waves from foreign earthquake have longer period, especially in the surface wave. In order to record these waves, the low-pass amplifier is employed. These seismograms are shown in Fig.5. Many phases relate to the earth's inner structure are clearly seen.

"Film case seismometer" (Make your own seismometer!)

Our seismograph system has high potential for seismic observation though it is fully handmade. However, production of these system requires precise skill through the making process concerned with metal devices, electronics and PC software. In this regard, now we propose a new easy making sensor worked as a seismometer and a new recording circuit, using only three IC, which is connectable through the PC's parallel port (Okamoto, 1997) .

<"film case" sensor (Fig.6) >

The vertical pendulum consists of serial connected rubber bands and a alnico bar magnet. The hanging bar magnet is placed in a film case wounding urethane coated coil as a sensor. To damp the fluctuation of bar magnet, salad oil is

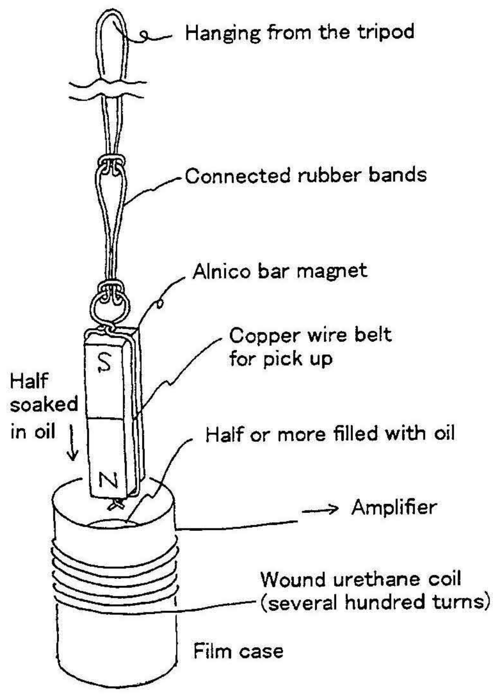

Fig 6. Film case sensor

half filled in the film case.

<Signal processing unit (Fig.7) >

IC1 and IC2 amplify the input signal as integrator. IC3 is a serial 8-bit A/D converter. Digitized signals are led into the PC through a parallel port.

< Software for signal display and auto logging >

The software which drives this seismometer is introduced with some modification of the previous system.

<Improved sensor (Fig.8)>

A modified sensor using a sample bottle and a copper pipe damper instead of a film case and oil is developed for precise measurement. Comparison of seismograms of this sensor and that of film case sensor is shown in Fig.9.

Acknowledgments:

We appreciate Mr. Dinesh Pathak for his useful comment in English. This study was partially supported by Grant-in-Aid for Scientific Research from the Ministry of Education, Science, Sports and Culture of Japan (No.09680207). The focal data sources used in this article are JMA (Japan Meteorological Agency) and USGS (U.S. Geological Survey).

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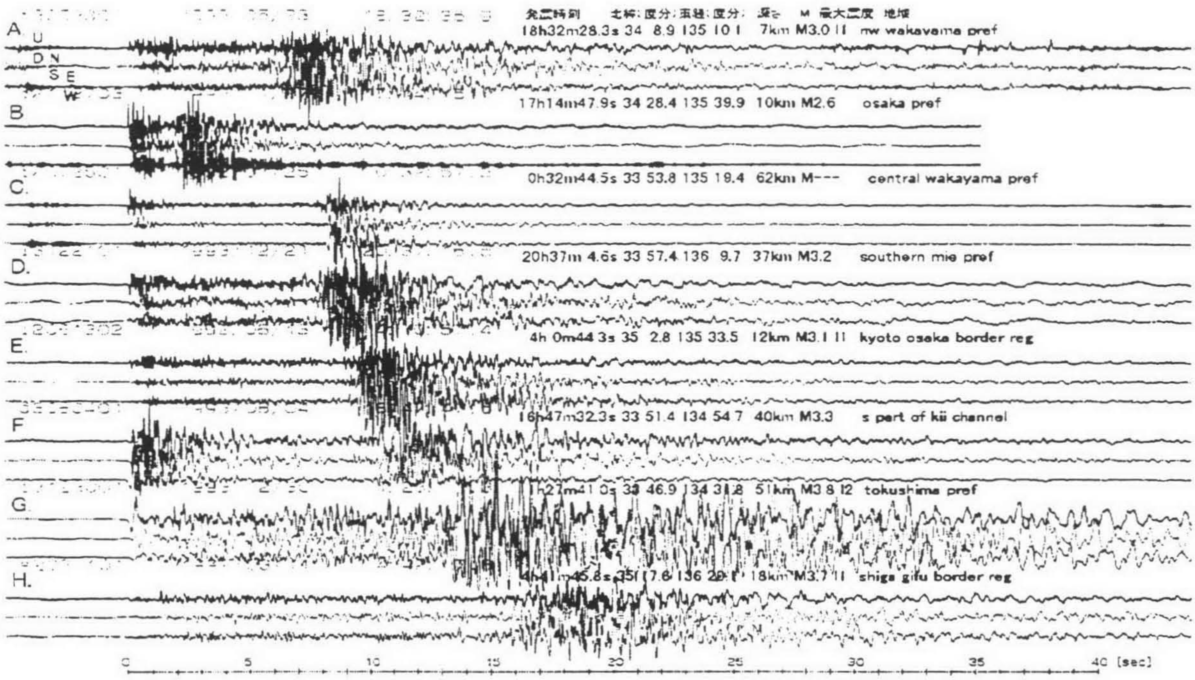


Fig .4 Seismograms of local earthquakes. (P and S phases are clearly seen.)

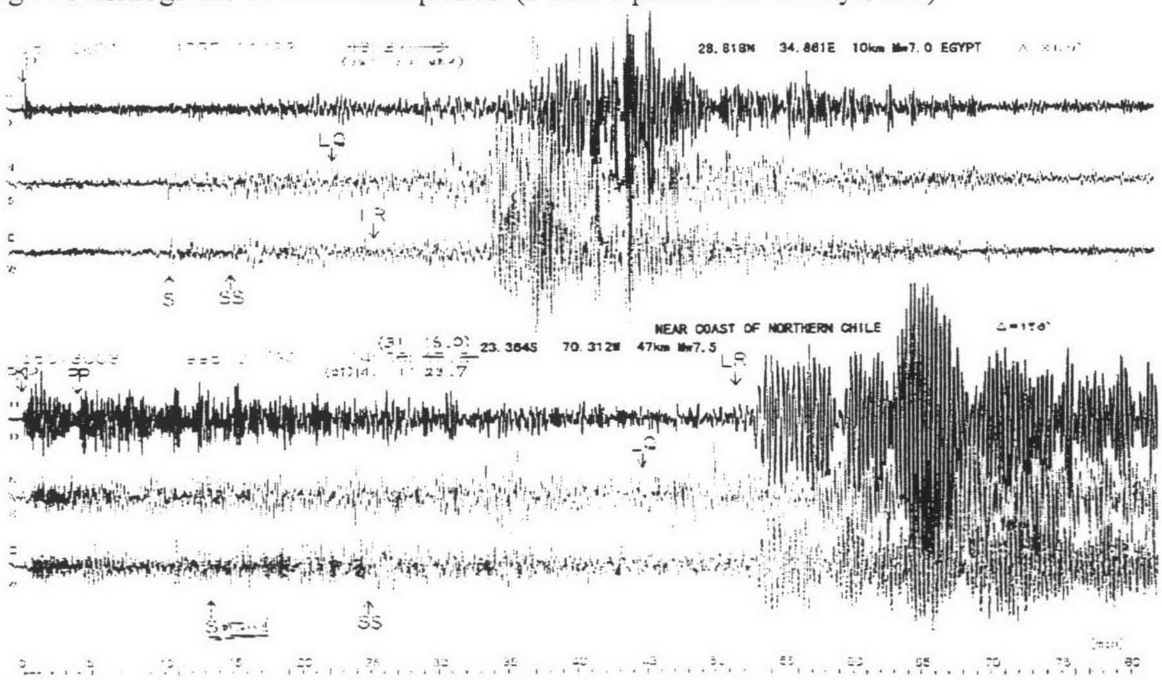
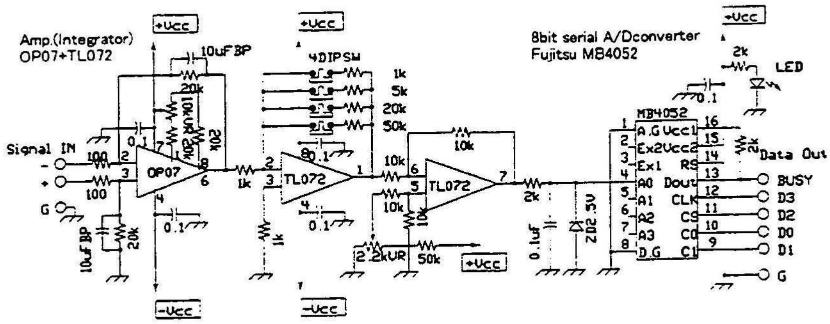


Fig.5 Seismograms of foreign earthquakes (Upper: Egypt Mw7.0 Lower: Chile Mw7.5).



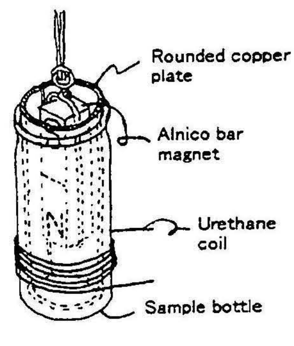


Fig.7 Signal processing circuit

Fig.8 Improved sensor

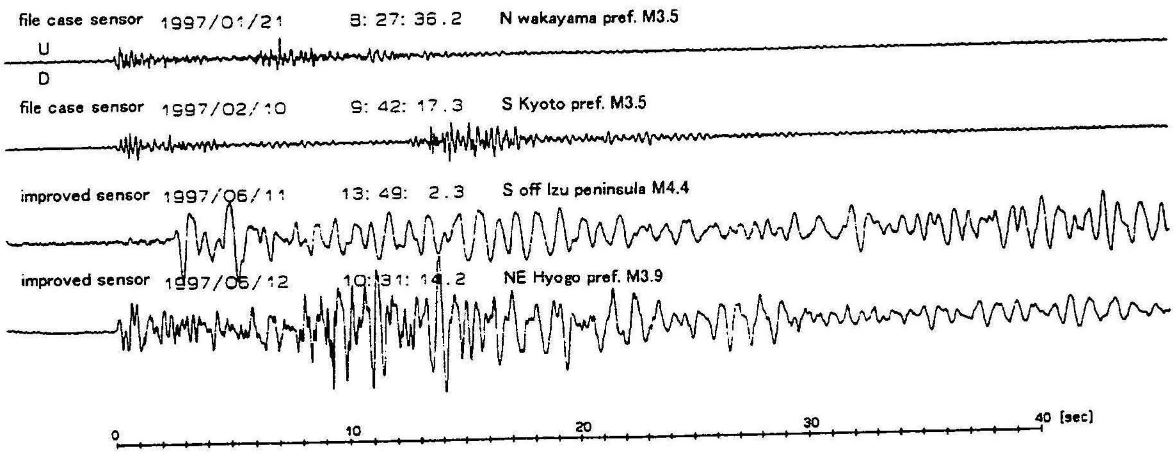


Fig.9 Seismograms recorded by film case sensor and improved sensor.
(upper two records: film case sensor lower two records: sample bottle sensor)

Using IT in the Teaching of Undergraduate Geoscience Courses

Anne Fernandez, Ian Johnston, Mary Peat and Kaye Placing

UniServe Science, The University of Sydney

UniServe Science, based at The University of Sydney, is a clearinghouse for information relating to the use of technology in science teaching. It was set up in 1994 to offer support and advice to teachers in Australian universities. More recently, the scope of UniServe Science has broadened to include secondary science.

UniServe Science aims to:

- promote, where appropriate, the use of new technologies in science teaching;
- advise academics of teaching materials that are available;
- evaluate science teaching materials (both software packages and Internet resources);
- publicise quality teaching materials, especially those developed in Australia; and
- encourage collaboration between academics, both nationally and internationally.

The web plays a major role in our ability to disseminate information to all Australian science academics. The UniServe Science web site at http://science.uniserve.edu.au/ has been designed for ease of use by busy academics, with easy navigation; clearly laid out pages; and rapidly loading pages. The site is regularly maintained and information is offered in a variety of formats to cater for individual requirements.

Some of the available resources of particular relevance to the Geosciences are:

- Newsletters (on-line and pdf);
- Workshop proceedings e.g. Tools for Flexible Learning;
- Brochures;
- Geosciences QuicKard - a summary of software used in first year undergraduate geography and geology courses;
- On-line searchable database of science teaching software, many with accompanying reviews by Australian academic commissioned by UniServe Science;
- Links to geography and geology departments in all Australian universities;
- Links to other useful sites such as virtual field trips and web-based interactive teaching resources;
- Mirror site for downloading *GeographyCAL* software (produced by the CTI Geography, Geology and Meteorology in the United Kingdom); and
- Tutorials related to the use of the Internet in Science Teaching with science related examples.

UniServe Science also hosts email discussion groups in all science disciplines including geography and geology. Information on subscribing to these lists is available from the UniServe Science web site.

Web Based Teaching Strategies to Initiate Interest in Earth Science Instruction

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Most teachers feel uncomfortable in discussing Earth Science topics in the classroom. This anxiety seems to increase through each level of instruction, and reaches a climax at the secondary level. The obvious reason for this awkward situation is the lack of formal training in the Earth Sciences and the pressures of an expanding curriculum that leaves little time to examine all physical sciences. When questioning teachers about the lack of Earth Science topics in their classroom, their response is the lack of training that they received for their teaching certification. They just do not have to take an Earth Science, therefore they avoid it in their teaching strategies. The flaw in this reasoning is disturbing to us who devote considerable time in promoting the Earth Sciences, because these topics are covered in national competency and entrance exams.

The world wide web and the general acceptance of computers as an integral part of the classroom has simplified the process of providing Earth Science teaching strategies. The amount and variety of information is overwhelming. The difficult task is in "weeding out" the superfluous sites and targeting those sites which contain the most relevant material for the intended age group. Local, state and federal government sites contain an abundant amount of information, but recent commercial domains are doing an extraordinary job in providing detailed web based instruction, particularly in Meteorology. The education domain has made considerable strides in providing appropriate information to use in all levels of instruction.

We have found that map interpretation is an effective method of taking information off the web and reproducing for general instructional purposes. In developing a graduate level class to enhance Earth Science material for the teachers we used several general sites:

- United States Geological Survey (hazards)
- Weather Underground (weather elements and severe weather)
- National Park Service (Parks, Monuments and National Seashores)
- National Park Conservation Association (environmental problems)
- Microsoft Terra server (air and satellite photo interpretation)
- Aquariums (Marine Sciences)
- Solar System (planetary characteristics)

Through a series of web based exercises the student is introduced to the Earth Sciences by using the excitement of searching the web, reproducing the information and interpreting cartographic material. We recognize that levels of Earth Science instruction vary from school district to school district, and state to state but, utilizing he web allows considerable margin for difficulty and intensity of student participation.

Fig 1. A recent photo of the BLUEsat team that appeared in the UNSW magazine 'Uniken'

Build your own Satellite: The BLUEsat Project

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The BLUEsat Project is currently under development by a motivated group of students with the support of industry at the University of New South Wales (UNSW). The **B**asic **L**EO **U**NSW **E**xperimental **Sat**ellite (BLUEsat) will be a small satellite constructed and operated from UNSW. A student-led, extra-curricular project, BLUEsat is now returning to the classroom as a very practical 'hands-on' approach to education.

Currently, the design and construction of the satellite is providing a range of engineering and technical education. A number of different schools and departments have created course material around the design and construction stages of the project. Next year will also see involvement in the project by High School students from around Sydney. Launch of

BLUEsat in 2002 will enable exciting opportunities for innovative approaches to education through the use of the colour Earth imaging capability that this tiny satellite will provide.

In it's 800km polar orbit, BLUEsat will be carrying a wide-angle colour imaging system. Adapted from existing video-conferencing and digital camera technology, it reflects a minimum cost solution to providing Earth imaging capability. With spatial resolution of approximately 1km, BLUEsat will provide broad global scale digital 'snapshots' of the Earth. Being a 10kg satellite measuring 23cmx23cmx23cm, this capability highlights that there are fundamental constraints of size, weight and complexity that this student project must work within.

While BLUEsat won't be pushing the limits of current image resolution or multispectral offerings of other remote sensing systems, it will provide an exceptional level of routine access to a space-based imaging capability for UNSW educational and research purposes.
Being managed from a Ground Control Station on the UNSW main campus, the opportunity will be available for the incorporation of timely images from BLUEsat into lecture material, lab and assignment work, or for general research. Further, broad exposure to the technical development of the Satellite itself will ensure a understanding of the technical and engineering concepts behind the images.

This approach can add a fresh and interesting approach to university education. Eventual World Wide Web linkage of the Ground Control Station to other sites can also provide access for High School education programs - enabling access to excellent resources that would otherwise be out of reach.

Highlighting what university students are capable of when prepared to put in some hard work and with good support, BLUEsat will go on to provide a multidisciplinary, educational legacy for ongoing groups of students at UNSW and beyond.

More information about BLUEsat can be found at http://www.bluesat.unsw.edu.au

Federal Coalition to Develop Integrated Geoscience Education Materials for the National Park System

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In the Spring of 1996, the U.S. Geological Survey began a partnership with the Shenandoah National Park, part of the U.S. National Park Service, to develop integrated science activities for secondary school students. Located in the Valley and Ridge Province of Virginia, the park is a natural hands-on classroom for field-based study programs that emphasize the multi-disciplinary nature of the Earth sciences.

In cooperation with the University of Virginia, secondary teachers obtained graduate credit for participation in the design and development of the activities. Over the course of three years, teachers, USGS research staff, and Park educational specialists held field trips, week long workshops, and writing and review sessions, resulting in the development of 5 integrated science modules.

Modules incorporate geology, hydrology, botany, biology, cultural and social history, and link understanding of these inter-related systems to relevant issues which face students in their communities. Developed within the context of the U.S. National Science Education Standards, and local State Standards of Learning, every module focuses student and teacher attention of critical concepts in the Earth sciences. We hope every student in the United States will learn these concepts in the course of their secondary education so that they can become discerning and active scientifically literate citizens for the 21st century.

Development of a simple and cost-less polarizing microscope for school use

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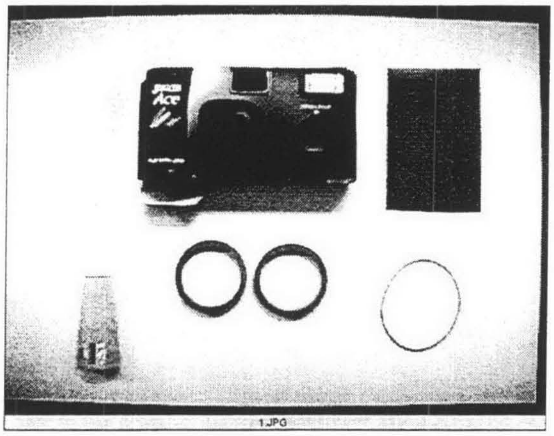
In the education of natural sciences practical work plays an important role. Similarly in the geoscience education looking at the pictures or watching videos is not enough, because lots of points might not have been shown or explained. Therefore, it is necessary that the students should be made to look upon the real material themselves and know its various properties. The practical work would boost the interest of students in studying geosciences and thereby raising the educational standard.

The geoscience curricula at the elementary school level include basic morophological structures on earth's surface and looking at some stones and volcanic stuff. The junior high school students are taught about changes taking place in the earth's shape and structure, rocks and minerals, volcanoes and their products, study of geologic strata and plate tectonics. At high school the curricula is more or less similar to that of junior high but the lessons are taught in more detail.
During these studies hand lenses and stereoscopes are commonly utilized which do not provide enough information and the lessons usually end up on watching videos and slides. To distinguish various minerals and study their properties, the use of polarizing microscope proves to be useful. However, due to high cost it is difficult to provide too many microscopes to schools. In present set up, junior high schools do not have polarizing microscopes where as in high schools their number does not exceed more than ten.

In this study we tried to prepare a simple polarizing microscope using waste materials. The material required included used disposable photo camera, plastic film container, polyvinyl chloride pipe rings, rubber band, polarizing film and quick binding glue. This material does not cost any money except for the polarizing film. The procedure to prepare this microscope is so simple that a Junior high school student can even make it.

First of all the batteries were removed from the camera to avoid any short circuit and then the convex lens from the viewfinder was taken out. Taking the focal length of the lens in consideration a 3-5mm slot in the body and a circular hole at bottom of the film container was made. The lens was fixed on the top of the film container's cap. Pieces of polarizing film were attached to the bottom and the cap of the container. Two polyvinyl chloride rings were tied together with rubber band and placed over the slot of the container. Cap was put back on the container before using for studying thin sections by inserting in between the two polyvinyl chloride rings.

This simple and easy to use microscope was utilized at various junior high and high schools and it was found that the students easily understood its principles and structure. The use of this microscope not only made them to distinguish minerals but also increased their interest about learning other sciences such as biology etc. Because of its easy preparation and usage this microscope can even be used at elementary school levels. Furthermore, students can easily prepare this microscope themselves.



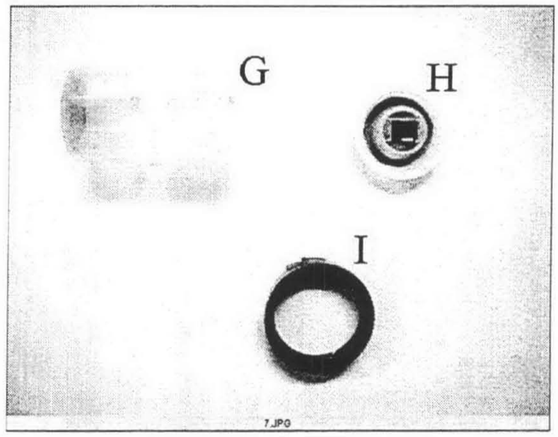
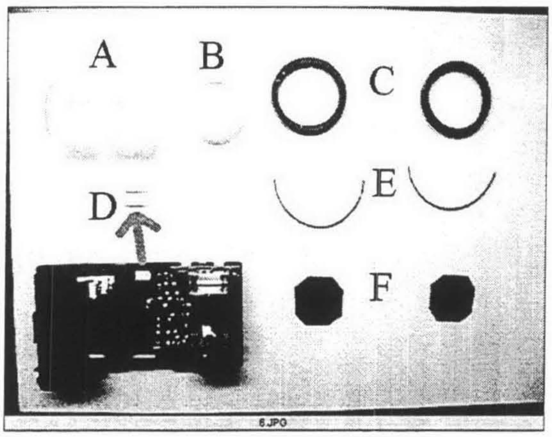


Fig. 1 and 2: Materials used for polarizing microscope. A, B= Plastic film container; C= Polyvinyl chloride rings; D= Convex lens from disposable camera; E= Rubber band; F= Polarizing film.



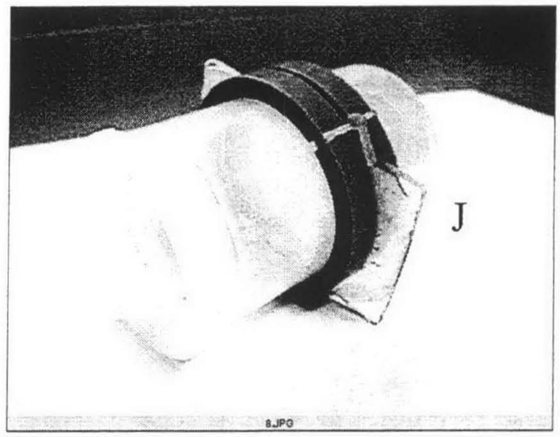
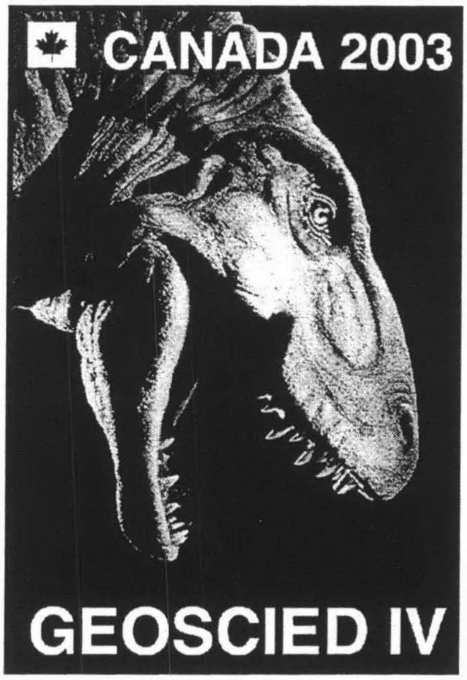


Fig. 3: Assembled Parts. G= A+F; H= B+D+F; I= C+E
Fig.4: Simple polarizing microscope with thin section inserted.



GEOSCIED IV - CALGARY, CANADA, AUGUST 10 - 14, 2003.

Geoscience Communication at the start of the 21st Century

We wish to extend a warm welcome to everyone interested in Geoscience Education to attend the 2003 Meeting in Calgary, Alberta.

Calgary is a dynamic city of 800,000 located on the Bow River at the junction of the foothills and prairies of Alberta. The city is the centre of Canada's oil industry and is the home of Canada's largest concentration of Earth scientists. It houses the Geological Survey of Canada's Western Office, the Alberta Energy and Utility Board's Core Research Facility. The city is within easy reach of the world-famous badlands of Steveville and Drumheller, as well as the entrance to Banff National Park and the Rocky Mountains of southwestern Alberta and British Columbia.

A field trip will be made to the Royal Tyrrell Museum of Palaeontology as well as to sites along the tributaries of the Red Deer River. A second field trip will go into the mountains to visit a number of classical localities. For those who are quite fit, a strenuous hike (weather permitting) will take them to the famous Cambrian fossil locality at the Burgess Shale UNESCO heritage site on the spur between Mount Wapta and Mount Field above the town of Field. Other visits on the montane field trip are tentatively planned for the Columbia Icefields and the Frank Slide as well as another World Heritage Site at "Head smashed in" Buffalo Jump, south of Calgary. We are also investigating whether delegates can participate in a real dinosaur dig!

The meeting will be held at the University of Calgary. The tentative theme of the meeting will be "Geoscience Communication at the start of the 21st Century", and we invite you to suggest possibilities for specific themes that will be of broad national and international interest to educators at all levels, as well as to science communicators.

Weather in Alberta at this time of year is usually excellent, normally sunny and dry, although there is a risk of rain. Weather in the mountains is highly variable!

Please visit our website at:
http://www.science.uwaterloo.ca/earth/geoscied.html

... and you might wish to check the "Discover Calgary" Web Site at:
http://www.discovercalgary.com/Calgary/

We look forward to seeing you in Calgary in 2003!

Those **!!??#* email queries: How geoscientists react and respond to them – a survey

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"In school we are studying volcanoes. As a final project, we are asked to get into groups and produce a short film on a pasific topic. Our topic is effects, hazzards and benifits of a volcano. Some subtopics we were asked to include in our film are: Lava flows, Pyroclastic material, Volcanic gases, Landslides, mudflows, and debris flows, Tsunamis, Hot springs, geysers, and geothermal heat, Impact on soil, Mineral formation related to volcanic activity, and Industrial products made from volcanic materials.

If you could please e-mail me, with any information on the topics listed I would greatly appriciate it. Thank very much for your time, Sincerely ….."

This is an email I received (spelling as it was) in the later part of my sabbatical with the United States Geological Survey in Menlo Park, California, and very soon after attending the 2nd International Conference on Geoscience Education (GeoSciEd II) in Hawaii. I viewed this email in many ways, asking for "the world" and I was suspicious of the individuality of the request. i.e. was I the only one to receive this email. Furthermore, I wanted to know if I would be alone in my ill feelings about this email, so I compiled a set of questions that I posted on the Volcano listserve and emailed to most of the participants of GeoSciEd II.

The questions I posed were:

1. I would like to know if this "resourceful student" has used a shotgun approach and emailed a number of persons in the Volcano Community. Has anybody else on Volcanolist received the same email?
2. This request asks for a lot and one could spend considerable time providing information on the subjects listed. Should we:
   (a) ignore this sort of request,
   (b) graciously give the student summaries of the topics one is familiar with,
   (c) not so graciously provide the student with detailed summaries and bibliographies of all of the topics listed,
   (d) inform the student of the existence of libraries.
3. Should we do the research that these students should be doing for themselves? Indeed, is this an acceptable form of research for these students, in that, is it really any different from those who chose to delve into reference books. I would value a discussion on this subject as it is becoming more and more common that "junior" school students are using and expecting email to be a resource collection facility.

This proved to be a "tasty bait" and I received 74 responses from 9 different countries, including the United States, Canada, United Kingdom, Zambia, Brazil, Italy, Korea, Australia and The Azores, ranging from a simple sentence response to 3 page epistles.

TABLE 1

Summary of the job categories of those who responded to the survey.

Category	Total (%)	Male (M) (%)	Female (F) (%)
Students (S)	4	33	67
Teachers (T)	15	27	73
Academics (A)	37	74	26
Working (W)	30	77	23
Others (O)	14	60	40

Responses to "Survey" (n=74)

A summary of the job categories of those who responded to the survey is presented in Table 1. Responses were received from the job categories of University Academics (A), working Geologists (W), teachers (T), students (S) and a few other people such as science editors and novelists (O). The source of comments is hereafter acknowledged by these job categories.

A selection of comments on the attitudes of people when they receive such email questions, their philosophies of how they are to be regarded, and the way in which they deal with them are presented here.

The Email Queries

- Should be regarded no differently from a letter in the post (W).
- A "problem" of increasing frequency (A,O).
- Sadly becoming commonplace (A).
- Asking Q's is not "doing research" (O).
- A "legitimate" request should indicate how the student located the address (A).
- No good reason for this kind of work for a school project (T).
- Obtains permission for her students before a professional is contacted (T).
- Should not do their homework (W).
- Learning how to think is important (A).
- Hard to stay civil when such requests received (A x 2).

A Response

- Serious mistake to ignore such requests (T)
- That you respond is important to the student (T)
- To answer them is not doing their homework (A)
- Any sign of negative attitude could result in loss of potential student and dislike of the geoscience community (W)
- Personal answer gives positive impression (W)
- Research should not be done for students (A)
- More willing to help people who have already made some effort (A)
- If information cannot be found in a book or URL one must respond (W)
- With email one can send a response and avoid guilt of enclosing more with it in an envelope (W)

Comments on the Teaching/Teacher

- OK request. Has had undergrads do similar information acquisition (A)
- Inform teachers to discourage this activity (O)
- Contact teacher (as teacher may not be aware of students activities), ask them to discourage this activity (A)
- Need to train K - 12 teachers on appropriate uses of email (A)
- Are teachers and librarians being trained in internet? (W)
- Worried about how children are being taught (O)
- Should be taught how to use a library (implied) (O)
- Teacher is exposing children to as many resources as possible (T)
- Indicates laziness on behalf of student and teacher (W)
- Lazy (W)

Comments on the Student and their Research

- Is trying to learn (A)
- Does not understand the magnitude of the question asked (A).
- Can't fault the students as they are naive and unaware of negative implications such questions may cause (O).
- Students should know how to use a library (O).
- Students should be taught to ask questions that can be answered (T)
- Students need to be trained how to ask questions (A)
- Students must learn to be good self-learners (T).
- Students are not being taught how to do research (O).
- Research can lead to new discoveries (A).
- To find clues to expand the depth of research and direction is a form of learning, and is not being taught (O).
- Kids have to do their own work, seek out resources and evaluate them (T).
- Asking questions of person at random is not "doing research" (O).
- Some one who wants to cut and paste his way to answer (A).
- Is asking scientists to be his secretary (S)
- If wants a secretary to do his work then he needs to aspire to such when he grows up (S).
- Is being lazy, naive (A).
- Students must learn to be more specific (A).
- Is misguided (A).
- Is lazy (W).

The Geological (volcanological) Workforce Attitude

- Even though there are lots of lazy monsters out there, I applaud the kids interest in the subject (W).
- This is the future. Opportunity for us to encourage learning (W).
- Important link encourages continuance of education (W).
- Need to improve perceptions and be ambassadors of science (A).
- Email to a professional scientist helps in the role of mentoring but ... (A).
- Takes pleasure in answering sensible questions (T).
- Flattered by being asked (W).
- A taxpayer vs government position = obligation to respond (A).
- Government agency = taxpayers questions are to be answered (A).

- Obligated to help on specific job related questions (A).
- Scientists have busy lives = not stand-in librarians (O).
- Will not reply unless specific to expertise (W).
- Not a scientists job to answer it. (A).
- "only so many hours in a day" (A).
- Isn't enough time to do these folk's research for them (A).

The Information/The Web

- Contact with a "real scientist" is a more current source (T).
- To get personal views would be acceptable research (O).
- Students have more access to current information than ever before (W).
- Needs to be an emphasis in the educational system for exploration of the electronic world (W).
- There is a cost to internet research (T).
- We should not provide research for "internet-savvy" students (A).

The possible actions that recipients of email queries can follow includes to:

1. Ignore the query.
2. Fully answer the questions posed.
3. Not answer the questions posed but point out a direction of research to follow by recommending:
   (a) use of school and local libraries,
   (b) textbooks,
   (c) the www, with specific URL's or keywords for searching.

7% of the respondents said they would outright ignore the request, and of them 60% were male academics and 40% male working geologists. An "ignore if too busy", was mentioned by one respondent. Thus, a resounding 93% said they would not ignore this or any email query they receive, with the overriding philosophy that we should "not discourage a student as they are a potential geologist of the future". Only one respondent indicated they would answer the question asked fully, with the rest indicating they would help the student to a base of resources.

Perhaps the most revealing thing to come out of this survey is the move away from the printed textbook as a source of reference to students, to that of the Web. Of those who said they would respond to the query the dominant suggestion by all groups was to refer the student to web sites, or to suggest a web search. 80% of the working Geologists, 75% of the Teachers, 70% of the Academics, 70% of the Students and 55% of the Others indicated that they would refer the student to the web. Reference to textbooks for research was recommended by less than 20% of respondents. Thus, textbook publishers, watch out!!!

A number of volcano related URL's, to which students could be directed to, were suggested by respondents. This prompted me to research and compile an extensive list list of Volcano-related Web sites which I have posted on the web at http://www.geology.unsw.edu.au/BuckVolc.html.

A selection of respondents comments on the ACTION one should take on the receipt of email queries is as follows:

Do's

- Reply to as in personal mail (T).
- Reply with enthusiasm (T).
- Be polite, constructive and encouraging (A).
- Reply with directions to resources (A).
- Encourage student to "dig for" themselves (A).
- Always give a positive response (W).
- Be a "mentor" to student (A).
- Help as far as one can (A).
- Answer, even if cannot answer all questions (W).
- Encourage to do own research (A).
- Reply, but without doing their work (T).
- Discourage "slothful approach" (O).
- Pick him up on his spelling (O).
- Ask student for name and address of teacher (A).

Don'ts

- Do not discourage with reply (S,A).
- Do not turn off student (T).
- Do not dent the enthusiasm (T).
- Do not ignore such requests (T)(A).
- Do not be un-cooperative but steer (T).
- Do not answer questions fully (S).
- Do not flippantly suggest "try your library" (W).
- Should not write and prepare a students assignment (A).
- Never do another's work (O).
- Do not send spelling corrections (T).

It is clear from "survey" that if you receive an email query from a student, you DO NOT ignore it. This applies no matter how busy you are, no matter who it's from, no matter how it is worded, and no matter how much it rankles you.

You SHOULD respond in a polite encouraging way. You should aim to play the role of "mentor" and envisage that your response could encourage the student to become a geoscientist in the future. However, while it is essential to respond, it is also essential that you DO NOT answer questions directly, and therefore do the research for them. Although, the exception to this is if the questions ask for information that is not readily available in either printed or electronic form.

A Model Generalised Reply

Several respondents sent me a "model response" on how they would respond to the email query. Using their advice and a few modifications, a model response to any (volcano related) query could be as follows:

Dear XXXX

I am pleased to see that you have taken an interest in volcanoes (or whatever). It is about at your age that I became interested in them too. Rather than answering your specific questions I will give you some suggestions on how you can find the answers to your question(s) by yourself. In doing so you will undertake an exciting quest.

If you have not done so already, start your quest by going to your school or community library where a "Reference Librarian" is available. It is their job to help you find your way around the library, but be patient as they may be busy. Ask for their help in how to find books on the subject you are researching and then seek to find the information to answer your questions by yourself.

Every library will have a set of encyclopedias and they may be a good place for you to start. Your library may have some books on volcanoes (or whatever), and, if you are really fortunate, one of the following books, which I recommend for your research, may be in the library: (Your book list)

If you are able to use the World Wide Web there are many good sites where you can find information on the subjects of your research. For example, ???? is a really great one to start with, as it definitely covers some of your subjects, and it also has links to other sites. Other sites that your could try are: (Your URL list)

If after your researches, you find yourself with some specific questions, then by all means send them to me and I will happily attempt to answer them.

Good hunting!

Establishing a Promotions and Education Program at the Geological Society of Australia

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Brief history of the Society

The Geological Society of Australia was established in 1952 with the initial objective to foster the publication of geological papers within a learned society. During the first year, the society grew to around 400 members and had established State Divisions in all six states, as well as the Australian Capital Territory. Its affairs were administered by the National Executive Committee, with Committees in each Division taking care of local matters. All positions were maintained entirely on a voluntary basis.

In 1960, a paid staffer was employed on a part time basis to maintain the office and assist the Executive. By 1977, the day-to-day administration of the Society was undertaken by a full time Business Manager.

The current Business Manager was employed in 1992. Until this time, most of the administration had focussed on membership matters, publishing the national journal and newsletter and managing the Society's finances. From 1992, and expansion began with the restructuring of the Society's operating activities and the installation of a new computer system, giving greater flexibility of access to membership details. An investment portfolio was established and has grown and changed with market fluctuations. The success of this portfolio has allowed the Society to become involved in a variety of new promotional and educational projects in recent years.

Trade booth attendance at conferences and the sale of Society publications broadened the reach of the Society and achieved greater exposure for earth science publications in the wider community.

An Executive Assistant was employed in 1994 for 2-3 days per week. This has now expanded to a 4 day per week position, allowing the Society to increase member services and undertake numerous new projects.

A Future Directions Workshop was convened in 1997 to discuss the aims and objectives of the Society, to address issues associated with the Society's internal operations, and develop new initiatives to improve the Society's external profile. The Society's Mission Statement was revised, with the new objectives "to promote, advance and support the earth sciences within the scientific and wider communities". The major outcome of the Future Directions Workshop was to employ a Promotions Officer at head office to coordinate Society public communications, media management and other promotional issues.

In February 1998, the Geoscience Promotions Officer was employed in a part time basis. After six months, the position was upgraded from 20 hours to 30 hours per week, then to a full time salaried position in January 1999. In January 2000 the title of the role was changed to Promotions and Education Manager.

The Society currently has around 3,100 members.

Major Promotional and Educational initiatives of the Society

Prior to 1998, limited promotional and educational projects (eg, subsidised student membership, in kind and financial support to other organisations' educational projects, corporate display booths at other conferences and events) had been administered by the Business Manager. Also, some Divisions with Education Sub-Committees produced leaflets and booklets such as roadside geology guides and information about sites of geological and heritage value. A Specialist Group in Geological Education was established in 1996 as a means of sharing information and ideas about geoscience education.

Over the last two years, promotional and educational projects undertaken by the Society have expanded at a seemingly exponential rate. Major examples follow.

EARTHWORKS – Earth Science, Technology & Minerals Learning Centre

The most significant project undertaken by the Society since February 1998 was the establishment of a new teaching and learning centre in Sydney. This initiative is a joint project between the Society, the NSW Minerals Council and the NSW Department of Mineral Resources.

Now in its second year of operation, the centre offers structured, hands-on learning experiences for upper Primary students (aged 9-12 years) and their teachers. Students work in small groups to complete the activities that are grouped into a number of themes. Activity sheets are sent to teachers prior to their visit so they can prepare for the session. A retired geologist is employed to facilitate the sessions.

EARTHWORKS is run on a very small budget and has relied heavily on contributions of equipment and educational resources from the three partner organisations. It is located in a disused laboratory of the Department of Mineral Resources, providing an authentic setting for scientific activities and experiments. One of the benefits of this location is the existence of an extensive collection of rocks, mineral samples and fossils that can be accessed and utilised for special events in the Centre. A more practical benefit is its proximity to the demographic centre of metropolitan Sydney.

We have conducted an ongoing evaluation of the Centre and its activities and have received greater than 85% positive feedback from teachers, students and parents. The NSW Department of Education & Training have supported the Centre throughout its development and operation.

New web site – www.gsa.org.au

A new web site was launched in January 1999, established via our own server and maintained from the Sydney office. Prior to this, our site was hosted by another organisation and access to it was limited. We believe an informative, up-to-date web site is a key promotional tool and an essential means of communicating with our members. The major sections of the web site are:

- Contacts – listing all Executive and Divisional office bearers and contact details
- Meetings – regularly updated list of Divisional meetings and events
- Conferences – Australian and international conferences and events of interest to our members
- Employment – information about science employment agencies and tips on finding a job
- Publications – the GSA publications catalogue (soon to include an on-line order form and secure payment system)
- Education – information for teachers and educators and links to useful sites
- Student Opportunities – listing Australian universities with Earth Science departments and some information about graduate and post-graduate courses

The average number of "hits" per day is over 100 and is increasing each month. Over the last twelve months, the most popular section has been the Employment page, a clear indication that we are providing a useful and valuable resource during this current downturn in employment for earth scientists.

Public Lecture Series

During Earth Science Week in October 1999, the GSA launched its inaugural Public Lecture Series. Our guest, Dr Walter Pitman from Lamont-Doherty Earth Observatory, New York, presented lectures in five Australian cities with the controversial title *Noah's Flood: The Geological Evidence*. This topic generated much interest from the geoscience community and general public alike, and we secured radio interviews and press articles in each city hosting the lectures.

Our aim with the Public Lecture Series was to present a stimulating geoscience topic in a responsible manner, with a solid basis in credible scientific research. We are confident we achieved a desirable level of public and media interest without sensationalising or undermining the science behind the topic, and intend to host similar events in future. For example, a major new event during July 2000 will be a Public Symposium at the Society's biennial Australian Geological Convention.

Mentor Program

The Sydney office and GSA Executive recently supported an initiative of the Education Sub-Committee of the ACT Division to establish a Mentor Program. The program, a joint initiative of the GSA ACT Division and the Science Educators Association of the ACT is currently being trialed in the Australian Capital Territory with professional earth scientists "mentoring" teachers and schools in their local area. Loose-leaf folders have been provided to both teachers and mentors giving information about geoscience education resources, products and services available to them in their local area.

This mentor program (detailed in Lawrie *et al.*, also in this volume) is an example of a successful collaboration between two professional associations effectively utilising the strengths and expertise of their members. If the trial is successful, the GSA intends to establish similar programs in other major centres around Australia.

Media articles

On an *ad hoc* basis, the Promotions and Education Manager has written earth science articles for *Australasian Science* magazine, Australia's only monthly science publication for a general readership. We hope to continue this public awareness role on a more regular basis in future by submitting monthly articles based on research papers published in the *Australian Journal of Earth Sciences.*

Political lobbying

One of the roles our members would like the GSA to play is that of political lobbyist. We are able to fulfil this role through our membership of the Australian Geoscience Council (AGC), which in turn is a member of the Federation of Australian Scientific and Technological Societies (FASTS), and by submitting reports and statements to various government reviews and inquiries. During 1999 the GSA sent three delegates to the inaugural Science Meets Parliament Day, organised by FASTS (and based on the Congressional Visits in the USA), where scientists held face-to-face meetings with Federal politicians from all major political parties. This major event was very successful and the GSA intends to participate in future.

The SWOT analysis

We have learned a lot from the experiences of the last two years - some projects have been extremely successful, others not so - and are now faced with the challenge of expanding our educational and promotional projects whilst remaining true to the aims and objectives of a learned society.

Strengths

- A large proportion of geoscientists in Australia are members of the GSA
- Breadth of expertise and geographical distribution of membership
- Three employed staff to maintain office
- Active Divisions in each Australian State and Territory
- 13 Specialist Groups provide activities, support and forums for a variety of earth scientists
- The biennial Australian Geological Convention is the largest earth science conference in Australia

Weaknesses

- Demands on members' and office-bearers' time increasing - less time for voluntary roles
- Two full-time and one part-time staff can only achieve so much
- Perceived focusing of resources in one geographical location, rather than national distribution
- Members of the public cannot easily locate us if they live outside Sydney or Perth (not listed in telephone directory elsewhere)

Opportunities

- Technology - much more email and internet communication allowing for "virtual" meetings, speedy and efficient information distribution and world-wide promotion of our products and activities
- Affiliations and joint associations with other professional organisations in Australia and overseas
- New earth science curricula in schools provide opportunities for involvement outside the professional sphere

Threats

- Major changes in national employment trends over the last year
- Downscaling and closure of university Earth Science departments
- Reduced government funding for earth science research

Summary

We need to rationalise our involvement and commitment to future educational and promotional projects to remain within the aims and objectives of a learned society. We have learned over the last two years that the most efficient and effective way to achieve results is to stick to what we do best - that is, being a learned society of professional earth scientists.

While we may not have the financial or time resources to produce glossy educational packages or products ourselves, we can utilise the strengths of our membership through programs such as mentoring, public lectures, media promotion and political lobbying. We can also support, either financially or in kind, the production of educational packages and resources by other kindred organisations that have expertise in producing these.

For example, the GSA cooperated with the NSW Department of Mineral Resources to develop mineral kits for distribution to schools in NSW, and provided funding for a field guide for members of the public visiting the Blue Mountains (called *Layers of Time*). We have also provided funding and other support to AGSO's Geoscience Education Unit to run teacher professional development sessions in a number of States.

By working together constructively we can expand the reach of our projects and achieve our overall objectives "*to promote, advance and support the earth sciences within the scientific and wider communities*".

References

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The development of the New South Wales Earth and Environmental Science Syllabus for 17/18 year olds

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The Board of Studies New South Wales, Australia

The Education Act 1990 established the Board of Studies New South Wales as a statutory body whose responsibilities are to:

- develop curriculum and support materials for all schools from Kindergarten (5/6 year olds) to Year 12 (17/18 year olds);
- develop and conduct examinations leading to the award of the School Certificate (14/15 year olds) and the Higher School Certificate (17/18 year olds);
- advise the Minister for Education and Training on applications for non-government schools seeking to operate in New South Wales; and
- grant permission to non-government schools to present candidates for the School Certificate and Higher School Certificate.

The Board's syllabus development process

The Board's syllabus development process involves consultation with teachers, academics and key education groups throughout five key steps:

- planning and promotion
- writing brief development
- syllabus development
- handover for implementation
- data collection and evaluation.

The development of the Stage 6 Earth and Environmental Science Syllabus

Planning and Promotion for the Stage 6 Earth and Environmental Science Syllabus (Nov 1997 – July 1998)

- A symposium was held in November 1997 to identify areas of strong agreement about the future directions for new Stage 6 science courses related to the areas of Biology, Chemistry, Geology, Physics and general science.
- A review of current literature and post compulsory courses in other states within Australia and in a number of other countries in relation to Biology, Chemistry, Geology and Physics was undertaken.
- The Board endorsed broad directions to be followed based on the recommendations from the symposium and the literature review and the analysis of the curriculum offered in other states and countries
- The Board's Inspector (Science) and the Board's Curriculum Committee (BCC) identified key groups for consultation and provided input on structure and content of courses

Development of the Writing Brief for the Stage 6 Earth and Environmental Science Syllabus (Aug 1998 – Nov 1998)

- A Project Team lead by the Board Inspector (Science) prepared a working draft of *writing brief* based on the endorsed recommendation of the Board. The draft *writing brief* provided a rationale for the course in Earth and Environmental Science, details about the aim, objectives and outcomes of the course and a broad framework for the development of course content.
- Consultation was undertaken by evaluation group independent of the Board and its Committees on the working draft of *writing brief* with:
    - the Board itself
    - the BCC
    - teachers, through a survey and focus groups across New South Wales
    - key groups including the Chairs of Academic Boards, the Department of Education and Training (DET), Catholic Education Commission (CEC), the Association of Independent Schools (AIS), NSW Teachers Federation, Independent Teachers Union (IEU), Science Teachers Association of NSW (STANSW), professional associations related to or with an interest in earth and/or

environmental science, tertiary educators, tertiary subject specialists in earth and environmental science, Parents' and Citizens Association (P and C), NSW Parents Council, Secondary Principals Council, Association of Heads of Independent Schools (AHISA), Aboriginal Education Consultative Committee (AECG)

- The independent evaluation teams compiled a consultation Report and made recommendation as to the revision of the draft *writing brief*. The draft writing brief was revised to take account of the recommendations and submitted to the BCC along with the Consultation Report.
- The BCC provided advice to the Board as to whether the recommendations from the Consultation Report had been acted upon in the revised *writing brief*.
- The Consultation Report, revised *writing brief* and the BCC Report were submitted to the Board for endorsement and subsequently sent to Minister for noting
- A briefing was held with school authorities and the endorsed *writing brief* was disseminated.

The Development for the Stage 6 Earth and Environmental Science Syllabus (Nov 1998 – May 1999)

- A Project Team lead by the Board Inspector (Science) prepared a draft *syllabus* based on the endorsed *writing brief*. The draft *syllabus* further developed the rationale for the course in Earth and Environmental Science, the aim, objectives and outcomes of the course. It also included the detailed content and assessment components of the course.
- Consultation was undertaken by evaluation group independent of the Board and its Committees on the draft *syllabus* with:
  - Board
  - BCC
  - Teachers
  - key groups (as detailed above)
- The independent evaluation teams compiled a consultation Report and made recommendation as to the revision of the draft *syllabus*. The draft syllabus was revised to take account of the recommendations and submitted to the BCC along with the Consultation Report.
- The BCC provided advice to the Board as to whether the recommendations from the Consultation Report had been acted upon in the revised *syllabus*.
- The Consultation Report, revised *syllabus* and the BCC Report were submitted to the Board for endorsement and subsequently sent to Minister for approval

Syllabus handover of Earth and Environmental Science (June 1999)

- A briefing was held with school authorities and the approved *syllabus* was disseminated.

Data collection and evaluation (2000- 2004)

- Information gathered by survey; targeting and interviewing of staff at a random selection of schools.

Features of the Stage 6 Earth and Environmental Science Syllabus

The Stage 6 Syllabus in Earth and Environmental Science (1999) represent a major reconceptualisation and expansion of the study and teaching of science at Stage 6 in New South Wales. Changes are reflected in:

- contemporary content that has been developed from a research base
- the development of the syllabus within a continuum of learning from Kindergarten (5/6 year olds) to Year 12 (17/18 year olds) across Prescribed Focus Areas, Domain and Context
- the course structure

Contemporary content developed from a research base

The syllabuses were developed following the Stage 6 Symposium and literature reviews that focused on the current scope of contemporary eduction, contemporary curriculum development and research in each area. The literature reviews pointed out that each of the sciences - biology, chemistry and physics and the geosciences were developed from human experiences with the planet earth and its relationship with the universe, and that the earth sciences should be broadened to include initiatives in atmospheric and space science, and oceanography.

There is, therefore, within the syllabus an increased emphasis on the earth as a complex planet with interacting systems - lithosphere, atmosphere, cryosphere, hydrosphere and biosphere and recognition that geology, physical and chemical, ecological and natural resources are major organising superordinate concepts.

Much of the literature reviewed highlighted the appropriateness of using the earth sciences to address environmental issues, natural hazards and consequent social problems, consequently the content of the course is integrated with issues related to natural resources, environmental quality and natural hazards where appropriate.

Some of the content areas identified in the literature review which were included in the course are:
- environmental geology which deals with the interactions between humans and earth materials and processes
- concepts that are basic to understanding the earth as an interacting system in space
- the earth's natural processes which take place over periods of time, from billions of years to fractions of a second
- the earth's subsystems (water, air, land, ice and life) which are continuously evolving, changing and interacting through natural processes and cycles
- planet Earth's finite heterogeneously distributed resources, renewable and non-renewable that sustain life
- the history of the landscape we live and the ways in which an appreciation of that history can affect how the landscape is treated
- the mobile lithosphere - plate tectonics

The symposium also emphasised the need for the course to provide students with access to relevant content linked to applications and research currently being undertaken by Australian scientists and opportunities to do this were included throughout the course.

The continuum of Learning

The syllabus is part of a Kindergarten to Year 12 continuum. Its objectives, outcomes and content are expressed in terms of Prescribed Focus Areas, Domains and Contexts. This model is used in the mandatory syllabus undertaken by all 12/13 to 15/16 year olds.

Prescribed Focus Areas

The syllabus identifies five emphases designed to increase students understanding of Earth and Environmental Science. These are:
History of Earth and Environmental Science
Nature and practice of Earth and Environmental Science
Applications and uses of Earth and Environmental Science
Implications for society and the environment
Current issues research and developments in Earth and Environmental Science

Students in NSW primary schools (5/6 to 11/12 year olds) develop a general awareness of aspects of the above Prescribed Focus Areas through the values and attitudes they are expected to develop. From the first year of their compulsory High School education (12/13 to 15/16 year olds) through to the HSC courses in Biology, Chemistry, Earth and Environmental Science and Physics the focus is on developing a more abstract understanding of each Prescribed Focus Area.

Domain

The Domain specifies knowledge and understandings and skills specifically related to Earth and Environmental Science that form the core of the course. The syllabus identifies, consolidates and builds on the knowledge, understanding developed in the primary and compulsory High School education in relation to:
- the resources of the Earth, particularly air, soil, water, minerals, their distribution and role in supporting living systems
- the abiotic features of the environment
- models to explain structures and processes of change affecting the Earth and its environment
- Australian resources
- Biotic impacts on the environment

The syllabuses also involves the further development of the skills from primary and compulsory High School education in the areas of:
- planning investigations
- conducting investigations
- communicating information and understanding
- developing scientific thinking and problem-solving skills
- working individually and in teams

Context

The Contexts are the frameworks devised to assist students to make meaning of the knowledge, understanding and skills of the Prescribed Focus Areas and the Domain. They allow teachers to engage students and stimulate their interests.

Earth and Environmental Science syllabus structure

The syllabus is divided into two 120 courses (a Preliminary Courses undertaken by 16/17 year olds and a Higher School Certificate Course undertaken by 17/18 year olds) each of which is traditional taught over a one year period. Students must complete the Preliminary Course before undertaking the HSC Course. Each course is further divided into four modules. Each module integrates the content from the Prescribed Focus Areas, Domain and chosen Context. The Preliminary Course provides a foundation for the concepts and skills developed in the Higher School Certificate Courses. The four Preliminary Course modules are:

- Planet Earth and its environment - a five thousand million year journey: allowing students to explore the theories proposed for the evolution of the solar system, the early evolution of the Earth and living cells and the evidence for those proposed theories
- The local environment: allowing students to identify the physical and chemical features of their local environment, relate these to the hydrologic, lithologic and atmospheric cycles in operation and to analyse those aspects of the environment that have been affected by people.
- Water issues: allowing students to investigate the interacting sub-systems of the Earth which together produce a unique biome, to discuss the importance of water in maintaining Australian environments and the policies and their effectiveness related to water resources past and present.
- Dynamic Earth: examining the evidence of present Earth structures resulting from tectonic forces and compares this evidence with the features of the Australian landscape with a view to understanding how the Australian continent came to its present shape and form.

The Higher School Certificate Course modules build upon the knowledge, understanding and skills of the Preliminary Course. It consists of three core modules undertaken by all students and one of four options. The core modules are:

- Tectonic Impacts: allowing consideration of the impact of tectonic plates over the long term Earth history and the impacts of earthquakes and volcanoes in recent history
- Environments through time: allowing students to explore palaeoecological and geological evidence to describe possible past environments of Australia, some modern theories that attempt to explain mass extinctions and consider the relationship between habitat alteration and the impact on life forms.
- Caring for the Country: allowing students to explore the fragility of the Australian environment, the carrying capacity of ecosystems, the pressures of urban, agricultural and mining practices and the strategies used to ensure ecological sustainability

The HSC options include: Introduced Species and the Australian Environment; Organic Geology - A Non-renewable Resource; Mining and the Australian Environment; Oceanography.

Open-ended investigation

In both the Preliminary and HSC Courses students are required to undertake at least one open-ended investigation integrating knowledge and understanding, and skill outcomes. This builds on the skills developed in the mandatory student research projects in the syllabus undertaken by all 12/13 to 15/16 year olds.

Assessment Components, Weightings and Tasks

There are two components to the final mark that a student receives for their Higher School Certificate. These consist of an internal assessment mark submitted by the school and an external examination mark. Based on a 3 hour state-wide examination set by the Board of Studies based on the HSC Course

Challenges faced in developing the syllabus

- Developing a course that would:
  - build on the four year mandatory course undertaken by all 12/13 to 15/16 year olds
  - attract a viable number of students
  - incorporate the recommendations of the symposium, literature review and the consultation reports
- Ensuring the efficacy of consultation process and that the consultation report accurately reflected the comments made
- Working with those committed to the structure/content of the old courses so that the new course was accepted
- Putting sufficient resources in place to convince teachers that the course should be offered

More information and copies of all Syllabus documents are available on the Board of Studies NSW web site at

www.boardofstudies.nsw.edu.au

Earth Science Mentor Program: A joint initiative of the Geological Society of Australia and Science Educators Association of the Australian Capital Territory

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Introduction

The Earth Science Mentor Program is a joint project between the ACT Division of the Geological Society of Australia (GSA), and the Science Educators Association of the ACT (SEA*ACT). The Program was developed with the aim of increasing awareness of the earth science among secondary teachers and students by providing the opportunity for interaction with, and support from, professional earth scientists.

The Mentor Program consists of an Earth Science Resource Folder for secondary science teachers, and a Mentor Folder for volunteer earth scientists. A brief training program and introduction to mentoring is provided for earth scientists, and mentors are assigned to teachers and schools by a central coordinator.

Development of the Program

The concept of mentoring is not a new one. Anecdotal evidence suggests that many geoscientists in Australia, including the ACT, have been providing an *ad hoc* mentoring service to teachers and students, and giving lectures to schools, for many years. Discussions with several geoscientists indicated that a more coordinated and organised approach to assist these volunteer efforts would be welcomed.

In tandem with these discussions the Education Sub-Committee of the GSA's ACT Division approached SEA*ACT in 1997 to jointly conduct a survey of secondary science teachers in the ACT. The surveys revealed that most respondents found geoscience interesting and stimulating, but problems arose when teachers who did not have geoscience in their training were required to teach the subject, and felt less confident doing so. There was consensus among respondents of the need to make geoscience more pertinent and relevant to everyday life.

Impetus to establish an Earth Science Mentor Program was borne out of a desire to coordinate and expand upon the existing *ad hoc* mentoring arrangements and to take on board findings from the teacher survey. During 1998 SEA*ACT agreed to develop a pilot Mentor Program with the GSA.

As a national, membership-based organisation (with around 3,100 members), the GSA is an appropriate coordinator of an Earth Science Mentor Program and supplier of "mentors". The program is supported within the GSA by the ACT Division and its Education Sub-Committee, the national Specialist Group in Geological Education, and by the Executive Committee who contributed $1000 towards to cost of producing the resource folders. Local industry in the ACT also supported the initiative through sponsorship of the folders. SEA*ACT have provided the necessary educational support at a local level and the program is supported nationally by the Australian Science Teachers Association (ASTA).

Earth Science Mentor Program – pilot study in ACT

The Australian Capital Territory (ACT) is an ideal place to trial an initiative such as the Mentor Program. The ACT has a relatively small population (310, 000 people) located within a small geographical area, within which there are around 30 secondary schools and colleges, including some in neighbouring Queanbeyan (southern NSW).

The ACT is also home to the highest concentration of earth science research and teaching centres in Australia, including Earth Science departments at the Australian National University (ANU), University of Canberra, and Canberra Institute of Technology, the Research School of Earth Sciences at ANU, the Australian Geological Survey Organisation, and soil, hydrological, hydrogeological and environmental geoscience research groups in CSIRO and within several Federal Government departments. Together, these produce a pool of over 500 earth science professionals and students in the ACT.

In addition, a new Earth Science Education Centre (ESEC) was opened in Canberra in October 1999 at AGSO. This facility compliments the role of AGSO's Geoscience Education Unit which produces geoscience education materials for teachers, students and the general community, and organises professional development sessions for teachers in major centres around Australia. Full time staff from ESEC will coordinate the pilot Mentor Program in the ACT.

Earth Science Mentor Program

A number of meetings during 1998-99 between both organisations resulted in plans to develop two loose-leaf folders (one for teachers, one for mentors), a list of geoscience volunteers, and a training session for these Mentors. Folders of a loose-leaf format would allow for updates and additional information to be included, ensuring they remained relevant and up-to-date for a considerable period.

Resource Folders and support for teachers

The needs of teachers had been clearly identified through the previous surveys and studies of geoscience teaching in the ACT, and during discussions with members of SEA*ACT.

The Earth Science Resource Folders contain the following sections:

introduction to the folder and the Mentor Program, including contact details for the organisers,

- list of geoscience education resources for the ACT, including relevant contact people and product catalogues,
- textbook index identifying geoscience topics and concepts in popular school text books,
- an extensive list of internet sites that contain geoscience information and/or activities that may be useful in teaching earth science,
- a list of commercially available multi-media resources,
- information about the GSA and SEA*ACT,
- a list of geoscience education events.

We have encouraged teachers to place the folders in a prominent place in their schools, to be shared with other teachers, and to add their own resources to the relevant sections.

The Resource Folders were distributed free of charge to all secondary school/college science departments in the ACT and Queanbeyan during Earth Science Week, October 1999. We plan to send a feedback questionnaire and update early in 2000.

TOTAL MEMBERS = 35

Mentor Folders and training for earth scientists

Many geoscientists already involved in their own "mentoring" have indicated that they cannot adequately meet all the demands of an enthusiastic teacher of school. Reasons given include:

- insufficient time to give lectures,
- insufficient knowledge about the geoscience curriculum within schools (and hence a difficulty in knowing how or at what level to pitch a talk),
- lack of knowledge regarding materials that are available to support geoscience teaching, and
- where a request had been made for lectures on specific topics outside their specialist knowledge, there was either a reluctance to burden colleagues, or inadequate knowledge of who might be available or willing to help.

The Earth Science Mentor Folders contain similar information to the Resource Folders for teachers, with one major addition:

- a Note to Mentors, outlining what mentoring is about, how the program will work, getting started with a school, options for types of mentoring activities, tips on giving in-school presentations and dealing with teachers and students, and contact details for the organisers,

Folders will be distributed to professional earth scientists who volunteer to become Mentors. A Mentor training session is planned for early 2000.

Where to now?

While the project is yet to get underway in full mentoring mode, initial feedback from teachers, educators and geoscientists has been encouraging.

One of the major challenges facing the long term success of the Program will be ensuring that regular contact is maintained with Mentors and participating schools and teachers. We need dedicated coordinators at the local and national level who are well informed about the Program and geoscience education activities generally. Major changes in employment patterns over the last year have significantly changed the nature of the pool of professional earth scientists available as Mentors.

If this "pilot" Mentor Program in the ACT is successful, similar programs will be established in other Australian cities and major regional centres. Discussions with other professional science teachers groups, such as ASTA, have taken place with a view to expand the mentor program nationally.

Is the Traditional Field Mapping Camp Obsolete?

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Abstract

Financial constraints on Earth Science Departments have called into question the value of undergraduate field based work, which is perceived as an expensive method of teaching. In addition, despite providing an opportunity to link theory with practice, the traditional style of field mapping camp may not adequately provide broader project and problem based teaching-learning opportunities. A new approach which allows field mapping to be carried out as a "real" piece of work rather than a "model of reality" provides multiple teaching and learning strategies to be applied and income from the client may facilitate running of the camp.

Introduction

The traditional Earth Science undergraduate field mapping camp was an exercise carried out in an area of variable geology where students were commissioned by their lecturer to map a set area of ground with a view to compiling the class work into a regional map. These mapping camps were generally the culmination of the practical part of the Earth Science course.

The diverse range of: rock and fossil identification skills, practical field techniques, structural geology interpretation, stratigraphic interpretation, compilation of maps, cross-sections and geological histories and other skills acquired in two or three years of undergraduate teaching were called upon in order for students to complete a single mapping task. As a mechanism for integrating most other parts of the Earth Science course the field mapping camp was an excellent exercise. However, in many cases field mapping was carried out as a "model of reality" which paralleled one aspect of the professional work environment, rather than a real exercise within the professional work environment.

In the best case scenario student field maps were later collated by staff members into a composite map that was field proofed and produced as a commercial map (McQueen et al. 1990). A number of years usually passed before sufficient mapping was done for this to be carried out. This also hinged on an academic taking on the considerable responsibility of compiling the work. Often the students who did the original mapping no longer identified closely with the final map as a product of their effort. That is, the majority of students no longer had a sense of "ownership" of the map product, if they new it had been produced at all. A more common scenario was that the same field area was visited year after year because teaching staff were familiar with the geology/soils that students were likely to encounter there. This mapping was carried out purely as teaching-learning exercises, and once the student maps were prepared nothing further was done with them. One obvious detraction from this method of teaching is that students could use the work from previous years to assist with compilation of their reports, rather than carrying out the exercise thoroughly themselves.

A new approach to field mapping has been carried out as part of Earth Science Fundamentals, a second year geology unit at the University of Canberra. Students coordinate their own mapping project and must produce their map and associated reports as a professional product for a client (Project Based Learning). In addition students must coordinate their own field work and deal with the problems of logistics such as coordinating vehicle use within the group or access to staff in the field (Problem Based Learning).

The effectiveness of this approach to experiential learning was assessed using student evaluation, professional peer evaluation (University staff geologists and geologists within the client organisation), community evaluation and self-evaluation techniques and by summarising the project outputs as performance indicators. The results of the evaluations were considered with respect to a review of principles of good practice in Earth Science teaching (Moore 2000).

What is Good Practice in Earth Science Teaching?

The principles of good practice in Earth Science teaching can be summarised by addressing a few simple concepts (Moore 2000). It is important to *link theory with practice* so that students can appreciate the application of the concepts being taught. The teacher needs to recognise that students have different *frames of reference* and hence *flexible learning paths* are required to present information in a variety of ways to facilitate student understanding. *Goals must be clear* for any project so that staff and students know what is required of them. *Staff enthusiasm* is infectious and stimulates student interest. Students' should be encouraged to *take responsibility for their own learning, which* not only enables autonomous study but also provides the foundations for life-long learning. The provision of *continuous student and peer feedback* is important to ensure that teaching practice is always evolving and improving. Implicit in this statement is the *willingness of the teacher to change practices*. Providing *feedback on assessed work* is essential for students to appreciate their *achievements and shortcomings* and be in a position to address these issues. *Co-operative learning* in preference to competitive learning generally creates a more friendly and encouraging work environment while still challenging individuals to work with others. Where possible, transparent links to employment paths provide incentive for students to undertake tasks.

Nature of the Project

Students mapped two by four kilometre strips in pairs and then compiled their map sections into composite maps within the group. Geological and regolith maps were generated for the field area, with associated notes relating to the lithologies and regolith-landform units identified. These maps were used by the client to interpret independently acquired geophysics surveys, to assist local Landcare groups with mitigation of salinity hazard and to aid with land management. All students presented seminars on their work to their peers. Nominated students presented the maps on behalf of their peers at a public presentation night.

Results and Discussion

In general a review of the questionnaires and discussion sessions, together with other performance indicators, reflected positively on the Earth Science Fundamentals field mapping camp. Students, staff, the local community and the client were all pleased with the outcome, although all parties highlighted areas that they would like to be addressed in preparation for the next camp.

The field mapping exercise succeeded in training students to view the environment in a new way. They developed their skills of observation, they recorded their observations (field notes, field mapping) and started to question (in camp discussion sessions) and put these observations in context (cross section interpretation, seminar preparation, final report writing). In this exercise students were compelled to link the theory of rock identification and rock and soil formation processes with their practical field mapping work.

The field camp assisted in reinforcing theoretical principals. Where student learning of theoretical concepts was shallow (rote learning or not learnt) this became apparent in discussion session in the field and could be addressed. An excellent example of this was a brief session in aerial photograph interpretation held early in camp that allowed students to review what they should have learned at the session held prior to departure. Being able to present students with field examples from their own mapping area greatly facilitated explanation of fundamental geological principals. The field camp also allowed students to develop their practical skills recognising that field mapping has traditionally been the backbone of regional geological projects.

The observation that students have different approaches to their learning was reflected in the variety of teaching approaches used while on field camp. These included: field demonstrations, mapping with a staff member, mapping in student pairs, evening presentations, classroom sessions, a field trip reviewing regional geology and salinity indicators, discussion sessions (formal and informal), seminar sessions and presentations to the public. Accordingly the assessment was distributed across a number of tasks that not only provided students with an opportunity to demonstrate what they had learned, but provided students with the opportunity to excel in their areas of strength, and still receive a balanced grade.

The goals for the field mapping exercise were clearly stated in a Project Outline and students were continually referred to this document throughout the field camp. The assessment requirements, reading list and layout for the final report were also detailed in this document.

The teaching staff interacted well with students and generally communicated principals clearly. In the period prior to the field trip staff access was limited but staff/student ratios on the field camp were excellent. Staff enthusiasm for the project was high and this probably assisted with keeping the exercise interesting. Staff and students felt that the field trip was fun. Features that contributed to this were: a mid-camp field trip which helped put the regional geology in context and provided a break from field mapping for a day, high quality of food and accommodation for the camp, warm community support and genuine interest in the project, free time most evenings for students and staff to relax, being out and about in the field each day, and having the opportunity to present to, and interact with the farmers.

Students spoke relatively openly in the field with staff members and didn't hesitate to let staff know about the aspects of the field camp they were not happy about. This is reflected in the observation that student and staff questionnaires and questions presented by both parties at the discussion session reflected similar areas of concern. Students completed the questionnaires and attended the discussion meeting quite happily, and were very open in expressing their opinions. They were prepared to contribute in order to improve the quality of the field camp for students in the year following them.

One very positive aspect of the field camp was the degree to which students managed their own field time, camp time, and staff interaction time. Coordination of vehicles, dropping students in particular parts of the field areas in the morning and collection at night was organised cooperatively between students and staff. Students took responsibility for their own food and water supplies and field and first aid equipment. Apart from some staff assistance to get started on the first day or two of camp, and some student directed discussion sessions to help with theoretical concepts late in the camp, students controlled their own learning in the field.

There were opportunities for individual endeavour (literature reviews, seminars, and final reports) and for contributing as part of a team (mapping in pairs, collation of regional map, construction of regional geological history). Students did not compete with one another but worked cooperatively toward a common goal. Even those selected to give a talk on the public presentation night operated as ambassadors for the whole mapping team, and discussed work collated from all field areas.

Students provided feedback on the best timing for the field camp with respect to when they received their grades. They also suggested that rather than parallel units taking them to similar field sites, perhaps some aspects of related units could be combined. This is an interesting comment considering that a negative observation from the review of student and staff evaluations is that a number of students failed to recognise the links between the field exercise and other related disciplines, especially those being taught concurrently in Earth and Land Science units.

This compartmentalising of subject matter was of particular concern to unit convenors in the Earth and Land Science course. One manifestation of this was student impatience with respect to soils based evening presentations that they did not perceive as relevant to the requirements for Earth Science Fundamentals. These presentations were, however, directly relevant to a former unit (Landscape Processes), parallel units (Australian Soils, Resource Information Systems, Regolith Studies and Catchment Processes) and subsequent units (Land Appraisal, Geographical Information Systems). This attitude may partially stem from the fact that many of these units had already been assessed prior to the field mapping camp. Another example of compartmentalising was the poor incidence of self instigated interaction between geology and soils students, and a disappointing expectation early in the exercise that this communication should be staff instigated. However, the 'us and them' attitude between students broke down fairly rapidly once all were interacting in camp.

The three most negative aspects of the review included the difficulty students had in accessing appropriate reading materials for preparation of their literature review, the lack of student understanding of what was required of them as far as the aerial photograph interpretation session was concerned and the limited access to staff over the summer period prior to field camp.

Other Performance Indicators

Other measures of the quality of the student and staff performance on the field mapping camp include the products of the exercise and the opportunities presented as a result of the exercise. The map was considered worthy of publication by the Centre for Australian Regolith Studies. Employing students to compile map notes and digitise the map provided them with some income and helped them develop skills in this area. The person who digitised the map also used it in an exercise for the 3rd Year unit Geographical Information Systems. In addition to providing the map to the Government client, a copy of the map was sent to the NSW Geological Survey as part of the compilation of the Boorowa 1:100,000 Geological Sheet and eventually part of the Goulburn 1:250,000 Geological Sheet.

A poster paper was presented on behalf of the group at the Australian Geological Congress, the largest Earth Science meeting of its kind in Australia, and the poster is now displayed in the Department hallway. This work also provided background to an Honours thesis carried out the following year. One of the most important aspects was that the local community, who supported the students while they were doing the work, benefited from the mapping via the local Landcare Group, and got to participate in the student presentation night. The clients have stated that they are happy to support future field mapping camps and were satisfied with the quality of the work.

From the students perspective they received: a personal reference from the client, assessment for their course, a reference for their resumes in the form of a published map, a copy of the map, their names on the poster presentation at the AGC, the satisfaction of making a contribution to local community, some managed to get summer employment with the client and one student gave a presentation using the field mapping exercise in an AusIMM Student presentation competition between three local tertiary institutions and gained second place.

Conclusion

The traditional field mapping camp should be modified so that in addition to linking theory with practice, it also allows for the application of multiple teaching-learning strategies. The concept that the mapping activities can be carried out not as "models of reality" but as "real" pieces of work which have clients that the students as a group are answerable to, not only adds an extra dimension to the incentives for carrying out quality work, but may facilitate running of the camp from a financial perspective.

The benefits to the broader community are many-fold, and considerably greater than in "models of reality" type exercises. The mapping exercise is more stringent, not only because the client requires products of a high standard, but because students take a great deal of pride in their mapping and reporting when working on a "real" contract. The ultimate benefits are greater in that the exercise can be considered as practical experience, the students have commenced networking in the work place, they have some experience of working in a real situation, they receive references from the client that can form a part of their resume, and they have experience presenting their work to the public. "Models of reality" exercises do not provide these opportunities.

The field mapping camp provides an opportunity to integrate a broad spectrum of student learning, and helps reinforce a deep understanding of the fundamental principals of Earth Science. Field mapping exercises continue to be one of the best forms of experiential learning for Earth Science students.

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What is Good Practice in Earth Science Teaching?

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Abstract

For effective evaluation of teaching and learning in any course, a frame of reference of what constitutes "good practice" is required. For Earth Science it is important to link theory with practice, provide flexible learning paths, state goals clearly, have enthusiastic staff interactions with students, provide opportunities for students to take responsibility for their own learning, be prepared to receive continuous student and peer feedback and take action with respect to this feedback, provide feedback on students' assessed work, encourage cooperative rather than competitive learning and provide transparent links to employment.

Introduction

Evaluation of the field component of the second year unit Earth Science Fundamentals at the University of Canberra was carried out in 1999 (Moore 2000). In order to evaluate the achievements and shortcomings of this course a list of principles of "good practice" in Earth Science teaching was required.

Results and Discussion

Linking of Theory with Practice

A career-path in the environmental sciences requires that students learn to view the world in an entirely new way. As a career Earth Scientist you do not simply carry out your duties from 9 am to 5 pm and then switch off your way of viewing your surroundings. Being an Earth Scientist is not what you do, but what you are. For this reason an important part of the training program for a profession in Earth Science should guide students to learn how to observe, record observations and how to evaluate and question the things they observe, rather than processing theoretical material in the manner of rote learning. The field component of an Earth Science course compliments work done in the classroom and laboratory, and allows students to actively engage in tasks which reinforce the subject content, and provides the opportunity to develop observation skills.

Flexible Learning Paths

Because students are individuals, each of them has a different frame of reference, usually arising from previous experience, within which new subject matter can be evaluated. The facility with which individuals grasp new concepts may be strongly influenced by this frame of reference, as it is easier to interpret new ideas if you already have a broad idea of context (Ramsden 1992, p 100, 101). In addition, individuals have preferred ways of learning new material. Some students learn by aural methods while others learn by responding to visual stimuli or by reading material and writing it out or by physically undertaking tasks.

There is no indication of one best way to teach (Ramsden 1992, p 87, 88) and it is therefore good practice to use a number of different teaching methods, within courses and within individual exercises. The best field mapping exercises therefore would have a holistic approach, where some material is presented aurally, and students are required: to do their own reading and literature evaluation, to develop observational skills, and to carry out relevant physical tasks. Because field exercises are frequently undertaken in groups, individuals may be able to learn and contribute within their particular area of strength. The provision of a field component within an Earth Science course may also provide those who are stimulated by visual or physical tasks with an opportunity to balance the theory component of their course.

Clear Goals

The principal goals for any course, and for individual exercises, must be stated clearly so that students and teaching staff can be certain about what is required of them. Goals should be presented in such a way that they can readily be referred back to. When addressing these goals there is a strong argument for teaching fundamental concepts well, rather than a broad range of subject material in a shallow way (Ramsden 1992, p 92-94). This reinforces the concept of teaching for understanding rather than having students absorb factual material without being able to apply this accumulated information to real situations. Field mapping provides an opportunity to link theory with practice in a tangible way. In order to effectively map an area, students must apply the knowledge and skills they have learned in other parts of their course.

Staff Enthusiasm

Teachers need to be able to explain concepts clearly while keeping the subject matter interesting. While there is no question that some teachers are better at this than others, being enthusiastic about the subject matter helps a great deal. A teacher's grasp of a subject has two parts: the teacher's knowledge of the subject matter and the teacher's passion for the subject matter. If teachers have a high level of knowledge and enthusiasm they are more likely to inspire students to be enthusiastic.

"The atmosphere of excitement, arising from imaginative consideration, transforms knowledge. A fact is no longer a bare fact: it is invested with all its possibilities. It is no longer a burden on the memory: it is energising as the poet of our dreams, and as the architect of our purposes."

(Whitehead, 1929, pp. 139)

Explaining why things need to be learned and how they may be used in the work place provides relevance to their study. Relating to students in a manner that is energetic and respectful breaks down barriers and enables the teacher to discuss not only course content, but also study techniques and student facilitation of their own learning. A significant aspect of being able to develop rapport with students revolves around establishing what the students' frames of reference for learning are. Once this has been done, classes can be pitched at an appropriate level for student understanding.

Students' Responsibility for Their Own Learning

A key to keeping teaching interesting is to make it fun. Many Earth Scientists were originally attracted to the career as students because of the field aspect and the idea of not being trapped in an office. Having a significant field component in Earth Science courses helps consolidate principles learned in class, and allows students and staff to interact in a less formal setting. In addition, democratic negotiation on the distribution of assessment, and some student control over the organisation of day to day tasks during field exercises, reinforces the concept that the responsibility for learning resides with both with the teacher and the student.

Despite being employed to teach within a particular discipline, most teachers are required to teach more than just the subject matter of a course. Students must be taught to take some responsibility for their own learning, and should be given the opportunity to carry out tasks independently. In addition to making the student more self-sufficient, independent research should reinforce student understanding of course subject matter, and helps prepare students for the responsibility of working independently once they are employed (Ramsden 1992, p 101).

Continuous Student/Peer Feedback

In addition to being able to talk with students, the teacher must also be prepared to listen to what they have to say. While students may not be well placed to advise about course content, they will be able to provide feedback on whether they are grasping concepts, whether they find particular teaching practices desirable or undesirable, whether the course organisation is logical, whether they are receiving adequate feedback, whether they are developing skills for working independently and in groups within the course, whether they feel assessment is fair, whether the goals for the course are clear and whether or not they think course goals are being met. Good practice dictates that the course should be flexible enough to be continuously modified in order to accommodate feedback, not only from students, but also from teaching peers, professional peers and as a result of self evaluation of teaching quality.

Feedback and Assessed Work
Providing feedback on students' work is essential. Feedback must be of high quality without being so overwhelming that it demoralises the student. Because it is also a requirement that students be assessed it is appropriate that, as a minimum, this feedback be provided on all assessed work, so that students are aware of where they made errors, and are able to adjust for this in future work. Assessment tasks should involve questioning in a way that allows students to illustrate their understanding of the concepts being tested. Assessment that simply requires the regurgitation of facts does not permit evaluation of the students' grasp of the subject matter. Field mapping requires integration of a broad spectrum of practical skills and theoretical knowledge, and is an exceptional method of reinforcing understanding while exercises are being carried out, and assessing how well concepts have been understood once the final map, cross-sections and reports have been handed in.

Co-operative Learning
Students must also be given the opportunity to interact with peers and teachers in a cooperative manner. The group approach to experiential learning, especially field mapping exercises, allows interaction not only with classmates and teachers but also with landholders and parties with a vested interest in the map products. Competition between students does not encourage sound interaction between peers, and this peer-interaction is essential for completion of regional field based exercises to which all class members contribute. Cooperative learning not only stimulates a camaraderie because students are working towards a common goal, but is usually a more effective and efficient way of approaching regional mapping projects.

Links to Employment
"Model of reality" exercises that involve learners in scenarios which parallel the real world are useful for training and allow students to have a taste of the professional experience (Print 1993). A superior exercise may be to arrange for students to undertake "real" tasks where they are providing a service for a "real" client and are learning through experience. However, for some students it is sobering to recognise that along with the "real" professional experiences comes a "real" responsibility for the project.

Conclusions

The principles of good practice in Earth Science teaching can be summarised by addressing a few simple concepts. It is important to *link theory with practice* so that students can appreciate the application of the concepts being taught. The teacher needs to recognise that students have different *frames of reference* and hence *flexible learning paths* are required to present information in a variety of ways to facilitate student understanding. *Goals must be clear* for any project so that staff and students know what is required of them. *Staff enthusiasm* is infectious and stimulates student interest. Students' should be encouraged to *take responsibility for their own learning, which* not only enables autonomous study but also provides the foundations for life-long learning. The provision of *continuous student and peer feedback* is important to ensure that teaching practice is always evolving and improving. Implicit in this statement is the *willingness of the teacher to change practices*. Providing *feedback on assessed work* is essential for students to appreciate their *achievements and shortcomings* and be in a position to address these issues. *Co-operative learning* in preference to competitive learning generally creates a more friendly and encouraging work environment while still challenging individuals to work with others. Where possible, transparent links to employment paths provide incentive for students to undertake tasks.

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