

STOW 96

Geoscience Education and Training

*In schools and universities, for industry and
public awareness*

Editors:

DORRIK A. V. STOW

COGEOED/AGID, Southampton University

G. J. H. McCall

Honorary Fellow, Liverpool University

Associate editors:

B. DALEY, J. W. GASKARTH, C. KING,

A. J. REEDMAN, I. D. SUTTON,

B. J. TAYLOR & D. B. THOMPSON

OFFPRINT



*Joint Special Publication of The Commission on Geoscience Education and
Training of the International Union of Geological Sciences and
The Association of Geoscientists for International Development, AGID Special
Publication Series, No 19*

A. A. BALKEMA / ROTTERDAM / BROOKFIELD / 1996

Geoscience education and training: Preparing for the 21st century

Dorrik A.V. Stow
*IUGS Commission on Geoscience Education and Training Geology Department, The University,
Southampton, UK*

Geoscience has a vital role to play now and in the future if we are to have the mineral, energy and water resources to sustain an ever increasing global population and if we are to manage, without major disasters, the fragile earth environment we co-habit. It is therefore essential that the geosciences are taught in a logical progression through all formal levels of education, that we are able to inspire our political leaders and decision makers with the relevance and importance of the subject, and that we further raise public awareness as to the value and interest of geology. In many countries and for too many years, the geosciences have been a small player and a poor relation to the mainstream sciences (physics, chemistry, biology). It is argued strongly here that this should no longer hold true and that geoscience is poised to become one of the major players in the 21st century, in the vanguard of the environmental movement and as a key focus for an integrated science syllabus at schools. It is further argued that the quality of education at all levels is as important as the content. Geoscience educators must recognise the responsibility of the learner to participate in the educational experience and must grapple with issues of larger class sizes, new developments in methods, materials and media, and the ever burgeoning information explosion. The participants at the International Conference on Geoscience Education and Training (Southampton, England, 1993) and the collected papers in this Proceedings Volume, testify to the wealth and vitality of ideas and developments in all sectors of geoscience education.

1 INTRODUCTION

Geoscience, geology, geological science, Earth-science – call it what you will, the terms are perfectly synonymous for one of the most fundamental and important of the natural sciences – the study of the whole Earth system. That study may be at the whole Earth scale, concerned for example with the driving mechanisms of plate tectonics, or at the micro-scale, unravelling the structure and evolution of planktonic microfossils. The study may be the very pure pursuit of knowledge and understanding of the Earth for its own sake, or very applied to the management of the Earth environment and its natural resources.

Just as there are many different strands to this complex and integrative science, so are there very different perceptions across the world as to its importance and relevance to today's society. At the Second South Asia Geological Congress (GEOSAS II) in Colombo, Sri Lanka, early in 1995, President Bandaranaike Kumaratunga opened the proceedings with the firm insistence that her Government 'is committed to the careful stewardship and sound management of the nation's mineral and agricultural resources, in order to achieve efficient and sustainable development.' This was not mere rhetoric designed to please an international gathering, it was a genuine and heartfelt sentiment, closely echoed and amplified by her Minister of Industrial Development in his opening speech. At about the same time, the US Congress voted by the very narrow margin of just four votes not to disband the US Geological Survey, one of the largest and most prestigious surveys in the world. This 'victory' followed a desperate lobbying campaign by geoscientists throughout North America.

In China, there is even a University of Geoscience, and the 30th International Geological Congress, to be held in Beijing in August 1996, will surely focus prominently on the political stage in that country. In the UK, about one-third of university geology departments were closed in the late 1980s as part of Government 'rationalisation' of the higher education sector. The current state of higher education in Britain and the need to prepare for the challenges of the 21st century have prompted the Association of University Teachers to write 'If the UK is to sustain a world class economy, staffed by world class people, the UK will call first and foremost on its universities. It will call for skills in managing resources, protecting the environment and shaping all aspects of social provision. Most of all, the UK will call for an educated and civilised citizenry.' This call to support the education sector is one that has been well heeded by the Japanese economic superpower, as well as by the rapidly developing economy of South Korea.

However, the state of geoscience education in a country does not always reflect the colour of the present government nor the perceptions of its leaders. Some generalisations can be made at the outset, based in part on contributions to this volume.

1. There is world-wide interest in restructuring the teaching of science towards integrated science curricula, and several industrialised countries have already moved significantly in this direction (e.g. USA, UK). This provides a golden opportunity for geoscience to take the centre stage as the integrated science of planet Earth (Mayer, this volume). It also provides a much needed impetus for the modernisation of outdated geoscience curricula.

2. There is further world-wide recognition of the potential dire consequences for civilisation as we know it if sound management of the environment is not immediately taken in hand. The geosciences are and must remain in the vanguard of a restructured educational system that takes due account of these issues (Carpenter; Aswathanarayana, both this volume).

3. In former nations of the eastern bloc, geoscience education has been marginalised and hence severely constrained for many decades (Kozák et al., this volume). There is much ground to be made up and great opportunity to take the best of what has been developed in other nations.

4. In developing countries, the picture is very variable. In some cases, curricula are outdated and teaching poorly supported by inappropriate materials; in schools, the subject is marginalised (e.g. Anguita & Doval, this volume). In other cases, the

subject has been newly introduced and curricula evolved that are directly applicable to the country's needs. Arguably, China takes the subject more seriously than anywhere, producing and utilising more geoscientists than anywhere. The Chinese Academy of Geosciences has been described as 'a cradle of young geoscientists' (Huàrui & Sijing, this volume).

So, while there is widespread recognition of the increasing need for a scientifically and technologically literate society world-wide, there is, within the Earth-science community, growing recognition of the fundamental role of geoscience education as a basic component of that global literacy. This is particularly true for the applied and environmental geosciences including the areas of energy, mineral and industrial resources, agogeology, geohealth and water resources, as well as land-planning, geohazards and environmental management in general. It is equally true that geoscientists face a severe uphill battle in many (most) parts of the world if they are to change the public understanding and political perception of their subject, and so place it rightfully centre stage in science education.

These points are among those iterated vociferously at the International Conference on Geoscience Education and Training (GEOED) held in Southampton, England in April 1993, and hence recorded in the papers of this proceedings volume. The aim of this paper is to draw together this wealth of data and ideas in order to highlight some of the most important trends and challenges that face geoscience education as it moves forwards into the 21st century. Afia Akhtar (this volume) summed up the sentiments of many when she stated 'everybody should have some idea about what geoscience is and how it affects our lives as well as our society.' But, just how is that to be achieved?

2 POINTERS TO THE 21ST CENTURY

There can be no doubting the practical importance that the geosciences must play as we struggle to manage the effects of an ever-increasing population on a planet of finite size and capacity. In my view, the educational advantages of teaching geoscience at all levels are equally manifest (see also, Orion, this volume).

1. Geology is a complex and integrative science that necessarily draws on many basic scientific disciplines in order to provide a holistic view of planet Earth, its structure and function, its history and resource base. The geosciences are therefore well placed to provide a focus for and framework of any integrated science curriculum at school's level. They can amply demonstrate the reality and practise of interdisciplinary science in action, as well as introduce and develop the concepts of time and space.

2. Geology is an observational and deductive science in the true tradition of the natural sciences. Its teaching must therefore introduce students to the scientific methodology of: observation – hypothesis – testing the hypothesis – deductive reasoning – conclusion. It has the further educational advantage of necessarily incorporating fieldwork and laboratory work into the teaching structure. Both of these aspects provide tremendous didactic opportunities if correctly utilised (e.g. Compiani & Carneiro, this volume).

3. Geology is, in part, a highly applied science of direct relevance to people and society everywhere. It is, furthermore, a keystone of the environmental sciences. Its teaching can therefore amply illustrate the practical importance of science in today's world, and raise both ethical and social issues germane to science (e.g. Nemeč, this volume). It can stimulate and direct students towards career choices that they may otherwise not consider.

4. Geology is a vital and intriguing science that can be made readily accessible at every educational level. It deals with the explanation of concrete, practical and everyday experiences, as well as the abstract and philosophical concepts of time and space and the human place within them. It deals with known, exact and provable science as well as the unknown and unprovable. What better subject to follow from kindergarten to university and beyond.

In many countries and for many years, geoscience and geoscience education has been a small player and poor relation of the so-called basic sciences (physics, chemistry, biology). It is argued strongly here that this should no longer hold true, that geoscience should become one of the major players in the 21st century, and that we are poised to take advantage of changing attitudes and a changing world in order to move geoscience centre stage.

Furthermore, as cogently argued by Nemeč (this volume): 'Increasing awareness of ethical issues at all levels of the educational process may be the only efficient remedy against the constantly increasing lack of morality in the world.' Such ethical issues can be made central to many aspects of geoscience education.

3 WORKING AT THE DIFFERENT EDUCATIONAL LEVELS

It is essential then that the geosciences are taught in a logical progression through all the formal levels of education as well as beyond and in the non-formal educational sector. This section examines some of the most important issues to be addressed at each stage.

3.1 Schools' level

'Few would argue with the need to increase the awareness of pupils age 6-18 with regard to environmental issues. Unquestionably, their generation will have to address issues that will profoundly affect their lifestyle and the quality of life for all life forms.' (Carpenter, this volume). And yet, the world-wide survey of the state of geoscience education at schools' level reported in this volume (Thompson & King, Part II) clearly demonstrates a serious lack of geoscience teaching, and more so of environmental geoscience, globally. It is under-represented in most developed countries, very marginal in many developing countries, and the poor relation as well as bedfellow to geography, biology or other sciences.

In Japan, South Korea, Israel and Jordan, however, the geosciences appear to be well covered and systematically organised from the age of 6 to 18, in recently reformed curricula (see papers by Isozaki, Lim & Jeong, Orion & Sotari, all in this volume). Similar curricula reforms in both the USA and UK have likewise given a much higher profile to geoscience teaching.

Whether these changes have already taken place, or whether the subject has still to move down and through the schools' curricula, educationalists in most countries would identify the following four key areas in which development is urgently required.

1. Geoscience needs a strong and unique place in the curriculum. This may be associated with other sciences or other subjects, especially in the early years, but it must be clearly introduced as Earth-science or geoscience. It should be closely linked with environmental issues and other applications where appropriate.

2. There is an urgent need for both new and in-service training of teachers in all aspects of geoscience, in how it relates to other subjects and to the world, in how best to teach it and in what materials are available as teaching aids. Further development of geoscience educational materials is an equally important and complementary requirement.

3. Planning carefully for a logical progression of geoscience topics and teaching from its introduction onwards is essential, so that each area is taught in appropriate detail and complexity, and so that tedious repetition through the years is avoided. In this regard, focus on the interfaces between the main educational levels is important – i.e. primary to secondary, and secondary to tertiary levels.

4. The educational potential of both fieldwork and laboratory work in the geosciences (as well as in other sciences) needs to be fully realised. Practical classes and field trips can too often be muddled and ill-conceived, whereas, with proper training and preparation they should take on a very important didactic role that clearly complements that of the classroom and books.

3.2 University level

'Higher education is not an option. It is the heart of our society as well as its brain' (Association of University Teachers, 1995). There are, indeed, some countries that recognise this with passion, where over 50% of the population continues passed school and into some form of higher education. But, in many others it has never yet approached that level of importance whilst sadly, in others, what used to be a strong and important higher education sector is becoming increasingly under attack and grossly underfunded.

It is against this varicoloured backdrop, where there is little standardisation of curricula or approach, that the geosciences must seek to figure prominently in the many changes and much rejuvenation that are currently underway. It is possible to identify the following four key issues and requirements.

1. Some form of curricula standardisation and recognition, always retaining special strengths and individual focus of different institutions or needs, would be a significant if difficult achievement globally. Modularisation of the degree structure is also considered an important development. Far from inducing grey uniformity where once there was variety, such changes would considerably enhance the potential for institutional and international interchange of both students and staff. Such tradition is part of the very essence of higher education, and becomes ever more viable and valuable as the global network of communications and transport improves so dramatically.

2. Any curriculum development must take full account of the following factors and support the diversification that will allow for: geoscience education for both vocational and non-vocational aims, with due emphasis on transferable skills training; and a strong bias towards applied and environmental geoscience and resource management where appropriate. Geoscience must play a full part in subsidiary education for other scientific disciplines, as well as engineering and other non-science subjects.

3. Greater attention must be paid towards improving the quality of geoscience education, including the general methods of instruction and assessment, interactive learning modes, information technology, fieldwork and laboratory work, and the multimedia support materials available for that teaching. At many higher education institutes, the didactic method has lagged seriously behind considerations of research excellence. This situation could easily be remedied.

4. It is equally important not to lose sight of the role of university education at the Masters and Doctoral levels. Resources, methods and standards need to be reviewed and improved at regular intervals, and international as well as within-country external examiners appointed where possible. Education to these levels need not be directly vocational and so due attention must also be paid to the research methodology and transferable skills.

3.3 Professional in-service training

'The problems of sub-Saharan Africa have their origin in environmental degradation... Training programmes in environmental management are therefore essential' (Aswathanarayana, this volume). Certainly, this is true and provides one of the important challenges for professional training in geoscience. Professor U Aswathanarayana goes further in his paper to address the three types of personnel that need to be trained in this area: (a) experts to prepare plans for ecologically sustainable development; (b) university level graduates (see above); and (c) village-level technicians to help put any grand plans into local practise.

A second key challenge, as already alluded to at the *Schools' Level* of education above, is the in-service training of teachers. This is an almost universal problem at present, from India to the USA, Japan to the UK, and one referred to in many of the papers in this volume. Some of the methods practised in the USA (Lojko & Buess, and Carpenter, both this volume) and the UK (Fisher, and Fleming, both this volume) could provide important models to be followed elsewhere.

Important for all professional geoscientists is building, improving and sustaining an information infrastructure that is able to handle and process large volumes of geological information, as well as to allow the interaction of these kinds of data with data from other relevant disciplines (Reedman, this volume). The information explosion is something that touches all countries and all subjects. Unless we learn to constantly upgrade and efficiently interrogate such data banks, then there will continue to be an enormous duplication of effort across the world and re-invention of the wheel every few years.

For each of the three areas outlined above, practical and effective methods of in-service training are often achieved by imaginative partnerships between different players including, for example, universities and schools, universities and industry, government and NGO, as well as international partnerships and training options.

3.4 Public understanding of geoscience

'There is dire need... to inspire decision makers at all levels of government to recognise that the science of geology is fundamental to the present and future social and economic development of the country' (Taylor, this volume).

'The biggest challenge of all is to raise public awareness of the value of geology, because this has the greatest implications' (Hamilton, abstract volume).

These two statements are really at the root of a great deal of very important activity that is steadily gaining momentum across the world. As stated at the outset of this paper, there are some countries in which politicians at the highest level seem to fully realise the importance of geoscience to national development (e.g. Sri Lanka), but this is not true of most. And, even in Australia, where there are some very exciting schemes for increasing public awareness of the subject, as outlined by Dr Jane James (abstract volume), the same author states: 'Public understanding of geoscience is, at best, minimal.'

It is perhaps in the realm of *public awareness* that geologists seem more able but still reluctant to act as educators. The role of National Parks and National and Provincial Museums is well demonstrated in several countries, including the UK (Reid, this volume), Jordan (Shahid, abstract volume), Canada (Rudkin, abstract volume) and the USA (Markovics, this volume). However, these are still isolated examples that simply form the tip of a very large potential. There is no reason why the multitude of exciting and intriguing facets of geology, from dinosaurs to gemstones, black gold to the Pacific 'ring of fire', should not capture the public imagination as has the natural world of animals and plants divulged from biology, or the mysteries of the universe as simply explained by astronomers.

Ecotourism is the fastest growing sector of the tourist industry in the 1990's and tourism world-wide is buoyant and expanding. The geosciences are well placed to contribute very significantly to these developments – indeed, we must ensure that they do.

It is in the realm of *influencing decision-makers* that geoscientists must find the inspiration and the method from somewhere. This is one of the least well addressed issues in this volume, and yet one with far-reaching implications for us all.

4 QUALITY CONTROL IN GEOSCIENCE EDUCATION: METHODS AND ISSUES

'Teaching approaches must change to emphasise the responsibility of the learner to participate in the educational process instead of being a passive receiver' (Fortner, this volume).

Education is, of course, as much about the method and approach as it is about the content. As a specialist in the content (geoscience in this instance), it is very easy to lose sight of the method so that teaching becomes second rate. There have been many advances recently in our understanding of how children learn science, how students perform best and how further and adult education should be undertaken. It is important that these advances in educational methodology are incorporated into the endeavours of geoscience educationalists at all levels. Indeed, in a number of countries at present, there is an emphasis on quality control in the formal education sector.

This is an excellent trend provided that any assessment of quality is then supported by measures to implement change and improvement.

However, it is not the intention of this paper to dwell at length on educational methods, but rather to highlight some of the many points that arose during the conference and to note some of the issues that need to be addressed as we move into the next century. Teaching approaches should aim to foster:

- Student participation in learning rather than acting as passive receivers;
- Self-motivation to learn and advance in knowledge and understanding;
- Critical thinking rather than idea/information parroting;
- The ability to find and access appropriate information data banks;
- The use of imagination and creativity where appropriate;
- The ability to follow a systematic scientific method of deductive reasoning;
- Competence at problem solving/overcoming a challenge;
- Student sense of purpose and direction in learning.

With regard to geoscience education in particular, but also of much more general application, the following issues are important ones to tackle now and for the future.

1. Class sizes at universities almost everywhere are increasing; at schools there is a constant battle to keep class size down. In both cases it has been amply demonstrated that the better education can be provided with a smaller rather than a larger group. There are clearly cost implications as well as organisational implications involved, but working with small groups is something that should be jealously guarded at all educational levels. Class size is especially significant for fieldwork and laboratory work in geoscience, particularly if the educational advantages of these are to be fully exploited.

2. Teaching and assessment methods must constantly evolve to take account of new research by educationalists, as well as in response to the availability of new media and materials and in line with changing class size. Every institute needs to have in place a carefully structured teaching and assessment plan and a well organised system to ensure its implementation and review. National and even international standards and guidelines must be considered important. What is abundantly clear and yet very little heeded, is that teachers, lecturers or other staff should have regular in-service training in educational methodology as well as in their particular subject area.

3. The medium and the materials available for teaching are constantly evolving. New schools packs with colourful posters and graphics are produced by an industrial concern; new videos on natural hazards are produced in the USA; IT software for explaining some difficult three-dimensional geological concept is marketed in Australia, and so on. The information network on what is available from where, and the distribution networks both within and between nations, have to be considerably expanded and developed if geoscience education everywhere is to benefit.

4. The information explosion in geoscience is every bit as large as in any other discipline, and is especially difficult to handle because it is such an interdisciplinary science. For teachers and even specialist lecturers to keep abreast of latest developments in their subject has become an ever more awesome prospect. In many parts of the world and at many levels of geoscience education, the information taught is seriously outdated. There is the technology to alleviate this problem, at least to some extent. We must ensure that such technology is fully developed for the easy use of geoscience educators.

5. Student-centred learning is not simply a *buzz phrase*, but something that needs to remain central to educational thinking through the next century. The student must take responsibility in the learning process at all levels. Materials, methods and different media all need to be user-friendly/student-friendly. Self-instructional and distance-learning packages and the full incorporation of IT software packages for all kinds of purpose should become a standard part of any student pathway through geoscience education. The learning experience should involve both independent and team work.

6. Central to the learning experience in all subjects must be the acquisition of *transferable skills*, including communication skills (written and oral), data gathering and manipulation (reading, library use, IT, networks), problem solving (individual and teamwork), and time management. These should be formally incorporated into the educational structure at different and appropriate levels. The geosciences offer excellent opportunity for developing all these skills, which can then be applied in whatever career pathway is subsequently followed.

5 CONCLUSION: ROLE FOR COGEOED

Geoscience is a live and vital subject for the world now and as we move into the 21st century. If we are to have the mineral and energy resources to sustain a global population of 6 billion, 10 billion, 15 billion or more; if we are to manage the fragile environment that we cohabit, mitigate against the effects of the worst natural hazards, and come to terms with global warming; if we are to maintain fertile soils for crops and adequate supplies of clean drinking water for all; if we are to bring each nation and all her people to enjoy the standard and quality of life that only a few now have, then there is no question that geoscientists have their work cut out for years to come. It is equally evident, therefore, that time, effort and resources must be put into geoscience education and training.

The International Conference that spawned this publication, the first of a truly international scope across the breadth of geoscience education, was full of energy and insight, of good practise and rewarding dialogue. Much of this is captured in the papers of this proceedings volume, but there is still much to come. There is also much to achieve, and this synthesis paper has attempted to highlight some of the key areas and issues that we need to address as geoscience educators.

It is very clearly the role of the Commission on Geoscience Education and Training (COGEOED) of the International Union of Geological Sciences to ensure that the momentum of the conference is not lost and that geoscience education continues to receive the attention it deserves. COGEOED therefore acts:

- To provide an international forum and newsletter on geoscience education;
- To organise conferences, workshops and symposia (e.g. IGC, Beijing, 1996; GEOED II, USA, 1997);
- To collate and distribute information on geoscience education materials, methods and curricula world-wide (e.g. GEM 2000+ programme);
- To promote and assist in the publication of relevant material (paper, IT and other media);

- To act as a live network for the exchange of information and ideas between a range of groups world-wide that share similar interests and to promote issues of common concern.

COGEOED works through a small international commission of core members and a wider network of corresponding members. It is not a closed shop and welcomes input from all interested parties.

FROM THE SAME PUBLISHER:

Stow, D.A.V. & G.J.H. McCall (eds.) 90 5410 657 3
Geoscience education and training – *In schools and universities, for industry and public awareness*
1996, 25 cm, 874 pp., Paperback, Hfl. 150 / \$85.00 / £61
Hardback, 90 5410 636 0, Hfl. 235 / \$138.00 / £96
This book has been prepared by AGID in association with COGEOED. It relates to an international conference held at Southampton, the first ever held on the topic on such an international scale and with such a breadth of topic coverage. The 90 or so submitted articles included in this work have been carefully structured under School Education (embracing school curricula and teacher training); University Education; Education for Business, Industry and the Public Service, Public Awareness and the Role of Women in Geoscience. Each section has concise introduction prepared by the section editor(s), the book is concluded by three impressions of the conference by senior delegates and the convenor, Dr. Stow; and also by a summary of the important points made in abstracts of talks not published here. There is a penetrating and questioning introduction to the book by Dr. McCall the volume editor, highlighting some of the problems raised in a set of papers which express a wide variety of viewpoints from many countries and professional spheres.

Stow, Dorrik A.V. & Deryck J.C. Laming (eds.) 90 6191 176 1
Geosciences in development – *Proceedings of an international conference on the application of the geosciences in developing countries, Nottingham, 26-29 September 1988*
1991, 25 cm, 327 pp., Hfl 165 / \$95.00 / £61

Berger, Anthony R. & William J. Lam (eds.) 90 5410 631 X
Geoindicators – *Assessing rapid environmental changes in earth systems*
1996, 25 cm, 480 pp., Hfl. 165 / \$95.00 / £67
This book introduces geological indicators of rapid environmental change, a concept developed as a contribution to state-of-the-environment reporting and to the assessments of ecosystem sustainability. Geoindicators constitute a new kind of landscape metric, one that reinforces the view of nature as changeable in ways that are not always predictable: humans are not the only cause of environmental stress. The book contains reviews of geoindicators for some major geological environments, glacial and permafrost terrains, groundwater systems, coasts, deserts, lakes, wetlands, soils and coral reefs. Other papers discuss geochemical, mathematical and policy frameworks for geoindicators. Included is the first edition of an international checklist of geoindicators, produced under the aegis of the International Union of Geological Sciences. These are described to a common format for use in monitoring geological change in any terrestrial environment. The book is of interest to a wide range of geoscientists and to anyone concerned with assessing sustainability through environmental indicators and monitoring.

Mulder, E.F.J. de & B.P. Hageman (eds.) 90 6191 706 9
Applied Quaternary research – *Proceedings of a symposium held at the XIIth INQUA Congress, Ottawa, 31.07-9.08.1987*
1989, 25 cm, 196 pp., Hfl. 150 / \$85.00 / £55

All books available from your bookseller or directly from the publisher:
A.A. Balkema Publishers, P.O. Box 1675, NL-3000 BR Rotterdam, Netherlands (Fax: +31-10-413-5947)
For USA & Canada: A.A. Balkema Publishers, Old Post Rd, Brookfield, VT 05036-9704 (Fax: 802-276-3837)