by Chris King

Geoscience education across the globe – results of the IUGS-COGE/IGEO survey

Director of the Earth Science Education Unit, Keele University, Keele, ST5 5BG, UK. E-mail: chris@cjhking.plus.com

An international survey of school-level geoscience education acquired data from 32 countries across the globe. Whilst the data is likely to be biased towards those countries which have geoscience educators active enough to respond to the questionnaire survey, the data nevertheless shows that geoscience is taught in a wide variety of contexts across the world, linked to science, geography or both. The majority of children in the countries surveyed had compulsory geoscience education in their curricula, had national standards in geoscience education, and covered a reasonable level of geoscience terminology in their studies. Optional geoscience courses were taught in most countries, but were only generally available to small numbers of 16-18 year olds. Undergraduate geoscience education courses were available in all the countries surveyed, together with graduate education in all but one. There was a wide variety of outreach initiatives recorded, with those in museums reported to be most successful. A general improvement was possibly discernible, but there is ongoing need of support from national and international geoscience organisations, together with need for increased funding and infrastructure and the raising of global awareness of the importance of geoscience education.

Introduction

The survey carried out in 2012 includes data from 32 countries across the globe.

The first international survey was carried out as part of the formation of the International Geoscience Education Organisation (IGEO) in Sydney in 2000. The IUGS Commission on Geoscience Education and Technology Transfer (IUGS-COGE) was formed in 2004 and a collaboration was developed between IGEO and IUGS-COGE to undertake a second survey, as the basis of a bid for International Year of Planet Earth (IYPE) funding. The second survey was carried out over 2005/6 and eventually included data from 27 countries. On the basis of the returns from these countries, a bid was submitted to the IYPE to run pilot workshops in geoscience education in three countries: the Philippines, South Africa and Trinidad and Tobago. The bid was unsuccessful.

During 2011, when a review was undertaken of the progress of IUGS-COGE, the Commission was asked to write an article for *Episodes* using the data collected in the international education survey. Rather than just depending upon the data collected in 2006, this seemed like an opportune time to update and expand the survey. Thus all the contributors to the 2006 survey were invited to update their data, whilst new members of IGEO and IUGS-COGE were contacted and asked to complete a questionnaire response as well.

The Third International Geoscience Education survey that resulted has now been published on the IGEO website (IGEO website) so that all those who contributed the data, and other interested people, can use the data collected, should they wish to.

No similar survey of the international state of geoscience education appears to have been undertaken or published previously.

The data

The survey published on the IGEO website contains data from the 32 countries listed in Table 1 and shown in Figure 1. Twenty countries provided data in 2012; for 12 countries, only the data from 2006 is available. All the contributors who kindly provided the data are acknowledged at the foot of this publication – but should not be blamed for any inaccuracies.

Inaccuracies may occur in the data or in the interpretation because:

- some questions were not clearly understood by some contributors, probably because English is not their first language;
- some of the answers provided were unclear, probably for the same reason;

Table 1. Countries which provided data for the geoscience education survey, with date of latest update

Country	Date of latest data update	Country	Date of latest data update
Argentina	2012	Malawi	2012
Australia	2006	New Zealand	2012
Bangladesh	2012	Norway	2012
Belgium	2006	Philippines	2012
Brazil	2012	Portugal	2006
Czech Republic	2006	Romania	2006
England	2012	Russia	2012
Estonia	2006	Saudi Arabia	2006
France	2006	Scotland	2006
Germany	2012	South Africa	2012
India	2012	Sri Lanka	2012
Indonesia	2012	Spain	2012
Israel	2012	Taiwan	2012
Italy	2012	Trinidad and Tobago	2006
Japan	2006	Uruguay	2006
Korea	2012	United States	2012

Figure 1. The distribution of countries which provided data for the geoscience education survey, with date of latest update schools – with thanks to Googlemaps. Countries providing 2012 data shown in pink, countries with 2006 data in yellow. This map can be found at: <https://maps.google.co.uk/maps/myplaces?vpsrc=3&ctz=-60&abauth=50155a03et2mAy988IYCS2vq4qAgZS4UXIw&vps=1&num=10>

- in order to summarise the data, simplifications were necessary, which may have led to inaccurate oversimplification;
- where a country has several states (eg. Germany, India, USA), the contributors pointed out that, because of variations across their countries, they have done their best to present a national picture, but this often just reflects the situation in some states.

Please report any inaccuracies to the author so that the data published on the IGEO website can be corrected and so that any further research based on this data is not compromised.

Note that the data may be biased by:

- colleagues from those countries willing to submit questionnaires; where countries have not participated, this may mean that school-level earth science education is less healthy;
- the experience and perceptions of those completing the questionnaires, ranging from Earth science teachers, to Heads of University Geoscience Departments and from teacher educators to government officials.

Data and analysis

Teaching approach

It was possible to identify eight different approaches to the school teaching of Earth science across the globe, as shown in Table 2, with the distribution shown in Figure 2.

The approaches and distributions show that Earth science is taught in a wide variety of different contexts across the world. Some patterns can be discerned, as follows:

- most Latin-American and southern European countries teach Earth science as part of 'Natural Science' where it is taught mainly by biology teachers;

- east Asian countries generally teach Earth science within science, where it is taught mainly by Earth science specialist teachers;
- in many countries, Earth science is taught both within science, by science specialist teachers, and in geography, by geography teachers;
- in some countries (Northern Europe), it is mainly taught only in geography.

Table 2. Approach to the teaching of Earth science in schools

Earth science teaching approach	Countries
Compulsory – part of Natural Sciences – taught mostly by biology teachers	Argentina, Brazil, Czech Republic, France, Italy, Portugal, Spain
Compulsory – part of chemistry and geography – taught mostly by these teachers	England, Sri Lanka
Compulsory – part of general science and geography – taught mostly by these teachers	Bangladesh, India, New Zealand, Norway, Russia
Compulsory – part of general science – taught mostly by these teachers	Israel, Philippines, South Africa
Compulsory – part of science – taught mostly by Earth science teachers	Japan, South Korea, Taiwan
Compulsory – part of geography – taught mostly by geography teachers	Belgium, Germany, Indonesia
Compulsory – part of primary science and geography – taught mostly by primary teachers	Scotland
Not compulsory	Malawi

Figure 2. The distribution of approaches to the teaching of Earth science in schools – with thanks to Googlemaps. This map can be found at: <https://maps.google.co.uk/maps/myplaces?vpsrc=3&ctz=-60&abauth=50155a03et2mAy988IYCS2vq4qAgZS4UXIw&vps=1&num=10>

These different contexts may affect the teaching style. For example, where Earth science is taught through science, more practical, hands-on approaches might be anticipated, whereas geography teachers may favour more map/ distribution/ hazards-based approaches.

National standards in Earth science

The majority of countries which contributed to the survey do have national standards for Earth science education, as shown in Table 3.

Table 3. National standards in school-level Earth science

Countries with National Standards in Earth Science		Countries with no National Standards in Earth Science
Argentina	Norway	Bangladesh
Brazil	Philippines	France
Czech Republic	Portugal	Germany
England	Romania	India
Estonia	Russia	Scotland
Indonesia	Saudi Arabia	
Israel	South Africa	
Italy	Sri Lanka	
Japan	Spain	
Korea	Taiwan	
Malawi	Trinidad & Tobago	
New Zealand	United States	

Ages of children covered by compulsory Earth science education

The compulsory coverage of Earth science is shown in Table 4.

The data shows that half the 5-7 year olds (52%) in the countries covered by the survey had compulsory Earth science education; four fifths of the 7-11 year olds (80%) were similarly covered, as were more than four fifths (84%) of 11-14 year olds and nearly three quarters (74%) of 14-16 year olds. However, only about a third of 16-18 year olds (35%) had compulsory Earth science coverage.

Table 4. The compulsory coverage of Earth science education (the 'Yes' responses are shaded)

Country	5 - 7 year olds	7 - 11 year olds	11 - 14 year olds	14 - 16 year olds	16 - 18 year olds
Argentina	Yes	Yes	Yes	Yes	Yes
Australia	Yes	Yes	Yes	Yes	No
Bangladesh	No	Yes	Yes	No	
Belgium	No	Yes	Yes	Yes	
Brazil	No	No	No	No	
Czech Republic	Partly yes	Yes	Yes	Yes	Yes
England	Yes	Yes	Yes	Yes	No
Estonia	No	Yes	Yes	Yes	Yes
France	No	No	No	No	No
Germany	No	Yes	Yes	Yes	Depends on the State
India	Yes	Yes	Yes	Yes	No
Indonesia	No	Yes	Yes	Yes	
Israel	Yes	Yes	Yes	Yes	Yes
Italy	Yes	Yes	Yes	Yes	Yes (in some schools)
Japan	Yes	Yes	Yes	Yes	Yes
Korea	Yes	Yes	Yes	Yes	Yes
Malawi	No	No	No	No	No
New Zealand	Yes	Yes	Yes	Yes	As part of Science or Biol
Norway	No	Yes	Yes	Yes	Optional
Philippines	Yes	Yes	Yes	Yes	Depends on school
Portugal	Yes	Yes	Yes	Yes	No
Romania	Yes	Yes	Yes	Yes	Yes
Russia	Yes	Yes	Yes	Yes	
Saudi Arabia	No	No	No	No	Yes
Scotland	Yes	Yes	Yes	No	No
South Africa	Yes	Yes	Yes	Yes	No
Sri Lanka	No	No	Yes	Yes	Yes
Taiwan		Yes	Yes	Yes	
Trinidad & Tobago	No	Yes	No	No	No
Uruguay	Yes	Yes	Yes	Yes	Yes
United States	Yes - in many states it is included in standards			No	No
Totals/31	16 = 52%	25 = 80%	26 = 84%	23 = 74%	11 = 35%

The data therefore indicates that there is reasonably good coverage in compulsory Earth science education across the globe – particularly for 7-16 year olds.

Textbook availability

The availability of textbooks and other teaching materials supporting Earth science education across the world is shown in Table 5. However, recent studies have suggested that many of these textbooks may contain poor quality material, with errors and oversimplifications (King, 2010).

Of the countries which contributed to the survey, more than half of 5-11 year olds (58% of 5-7 year olds, 52% of 7-11 year olds) had no textbooks and teaching materials, or materials of only poor quality; a third of 11-16 year olds (35% of 11-14 year olds and 42% of 14-16

year olds) had no or poor quality materials, whilst more than a third (39%) of 14-16 year olds were in a similar position.

If textbooks and teaching materials are poor or non-existent in more than a third of the countries surveyed, it might be construed that teaching is also poor in those areas. Even in those countries where better teaching materials are available, there may also be cause for concern if these materials are of poor quality and contain misconceptions.

Benchmarking on the basis of geoscience terms in the curriculum

The benchmarking attempt was made on the basis of the 124 geoscience terms shown in Table 6. Contributors were asked to indicate at which levels, if at all, these terms appeared in the

Table 5. Availability of textbooks and other teaching materials (the positive responses are shaded)

Country	5 – 7 years	7 – 11 years	11 – 14 years	14 – 16 years	16-18 years
Argentina	Poor				
Australia	No	Some	Some	Some	No
Belgium	Some	Some	Some	Some	Some
Brazil			One		
Czech Republic	Some	Some	Some	Some	Some
England	No	Some	Some	Some	Two
Estonia	No	Yes	Yes	Yes	Yes
France			Yes	Yes	Yes
Germany		Book and CD-ROM			CD-ROM (11 Modules)
India	A range of materials, including textbooks, guides and other materials is generally available.				
Indonesia	No	No	Geography textbooks	A geography textbook	
Israel	Yes	Yes - extensive	Yes - extensive	Yes - extensive	
Italy	Textbooks, CD-ROMs, videotapes, DVDs				
Japan	Yes – by Ministry of Education				
Korea	Textbooks by the national agency		Textbooks and other teaching materials by several publishers		
Malawi	Texts are available (geography) at all levels but are out-dated.				
New Zealand		Poor	One	One	
Norway	Several textbooks in geography and general science are available				
Philippines	Yes	Yes	Yes	To be developed	
Portugal	Textbooks	Textbooks	Textbooks/worksheets	Textbooks/worksheets	Textbooks
Romania		Yes	Yes	Yes	Yes
Russia	Yes	Text book in nature	Text book in geography	Text book in geography	Text book in geography
Saudi Arabia					Yes, textbook
Scotland	Yes				
South Africa	Yes		Yes - of variable quality		
Sri Lanka	No	No	Basic concepts included	Basic concepts included	Geography textbook
Spain	No		Textbooks, CD-ROMs, videotapes, DVDs in Spanish + other langs.		
Taiwan	One	One	One	One	
Trinidad & Tobago	Textbooks, worksheets	Textbooks, worksheets	Textbooks, worksheets	Textbooks, worksheets	Textbooks, worksheets
Uruguay			Geography	Geography	
United States	FOSS (Full Option Science System)	ESIP (Earth Systems Programme Implementation Project) Project	Investigating Earth Systems (IES) curriculum Project CUES	EarthComm curriculum http://edmall.gsfc.nasa.gov/aacps/curriculum.html	Advanced Placement Environmental Science
Good quality total/31	13 = 42%	15 = 48%	20 = 65%	18 = 58%	19 = 61%

Table 6. Terms used to benchmark the Earth science content of the curriculum across the world

General material/ process terms (37)	Plate tectonic and Earth structure terms (12)	Geological time and evolution terms (8)	Natural resource and natural hazard terms (28)	Rock types (19)	Approach – terms used in an Earth science context or in a general context that applies to Earth science (20)
<ul style="list-style-type: none"> • Mineral • Fossil • Rock • Soil • Atmosphere • Carbon cycle • Water • Water cycle • River/lake • Sea/ocean • Coast/beach/cliff • Mountain/ hill Valley • Wind/eolian • Ice/glacial • Rock cycle • Weathering • Erosion • Deposition • Lithification/ compaction/ cementation • Sediment/ sedimentary • Metamorphic • Igneous • Volcano/volcanic • Eruption • Magma • Lava • Ash • Melting/melt • Partial melting/ melt • Fractional crystallization/ magmatic differentiation • Earthquake • Seismic/P/S waves • Focus/epicentre • Fold/ folding • Fault/faulting • Deformation 	<ul style="list-style-type: none"> • Plate tectonics/ tectonic plate • Lithosphere • Asthenosphere • Subduction • Magnetic stripes • Polar wandering • Mountain building/ orogeny • Continental/ oceanic plate • Crust • Mantle • Core • Outer core/ inner core 	<ul style="list-style-type: none"> • Geological time/ timescale • Dating • Correlation • Stratigraphy • Earth history • Evolution • Natural selection • Fossil record 	<ul style="list-style-type: none"> • Energy source/supply • Renewable/ non renewable • Sustainable/ sustainability • Groundwater • Pollution • Acid rain • Ore • Mine/mining • Quarry/quarrying • Borehole/ well • Fossil fuel • Coal • Oil/ crude oil • Gas/ natural gas • Hydroelectric power • Solar power • Wave power • Wind power • Power from biomass • Landslide/ landslip/ rock fall • Lahar • Nueé ardente • Tsunami • Storm • Flood • Natural hazard • Prediction/ forecast • Disaster planning (or similar) 	<ul style="list-style-type: none"> • Sandstone • Limestone • Shale/ mudstone/ clay • Conglomerate • Coal • Peat • Slate • Schist • Gneiss • Marble • Quartzite/ metaquartzite • Granite • Gabbro • Basalt • Dolerite • Volcanic ash • Andesite • Rhyolite • Peridotite 	<ul style="list-style-type: none"> • Sort/ sorting • Identify/ identification/ recognise • Classify/ classification • Describe/ description • Measure • Explore • Explain/ explanation • Fieldwork/ in the field • Plan • Observe • Experiment with • Interpret • Analyze • Give evidence • Predict • Apply • Evaluate • Enquiry • History of science • Map/ mapwork

curriculum. 25 questionnaire responses were received, and the results are shown in Table 7.

The data shows that, on average, 79% of the 124 terms are found somewhere in the curriculum, broken down to 6% of the terms for 5-7 year olds; 23% of the terms for 7-11 year olds; 45% for 11-14 year olds; 49% for 14-16 year olds; and 58% for 16-18 year olds.

It is not surprising that an increasing number of the terms appear in the curriculum as the ages of children increases. It is also not surprising that all the terms don't necessarily appear at the higher levels, since some may be simpler terms, more appropriate for younger children.

Overall, it could be argued that a reasonable number of geoscience

terms is covered by Earth science curricula across the world, even though the situation is rather 'patchy'. This 'patchy' nature can partly be explained by some countries publishing detailed content-filled curricula whilst others have adopted a more 'umbrella' approach, of publishing broad Earth science statements and leaving teachers and examiners to provide the necessary detail.

Availability of optional geoscience education courses

The availability of optional courses in school/college-level geoscience education is shown in Table 8.

The data indicates that, of the countries covered by the survey,

Table 7. Summary of benchmarking data (based on the 124 terms listed in Table 6)

Country	Term is present in curriculum	For 5 – 7 year olds	For 7 – 11 year olds	For 11 – 14 year olds	For 14 – 16 year olds	For 16 – 18 year olds
Bangladesh	11	0	0	11	0	0
Belgium	108	15	44	30	56	105
Brazil	72	0	0	61	15	0
England	60	7	17	40	25	0
Estonia	120	0	47	80	116	120
France	124	1	7	71	111	124
Germany (Lower Saxony)	42	0	2	27	7	12
Indonesia	112	5	10	65	93	112
Israel	112	18	62	92	94	112
Italy	55	15	5	23	14	28
Korea	123	20	79	113	121	123
Malawi	85	8	35	47	53	85
New Zealand	91	7	25	74	43	37
Norway	48	1	10	12	24	43
Portugal	105	20	54	73	87	85
Romania	104	3	18	73	91	104
Russia	128	6	33 - 35	60	26	0
Scotland	31	0	1	14	0	0
South Africa	96	2	3	49	76	107
Saudi Arabia	118	1	9	11	11	86
Sri Lanka	102	5	15	43	91	102
Spain	124	41	85	103	116	124
Taiwan	96	15	40	83	107	97
Trinidad & Tobago	76	19	25	46	36	48
Uruguay	108	0	66	94	103	103
Mean/25	89 = 72%	8 = 6%	28 = 23%	56 = 45%	61 = 49%	72 = 58%

nearly two thirds (61%) have optional geoscience education courses and that these are mostly available to 16-18 year olds in small numbers of schools. Where they are available, they usually can be used to contribute to university entry qualifications. Whilst the global availability of such courses is to be welcomed, it is concerning to note that they are generally only available to small numbers of 16-18 year olds in most countries.

Earth science outreach

Different types of potential Earth science outreach are shown in Tables 9 and 10 with a perception of their effectiveness and how widespread they are.

The data indicates that, where available, the different forms of outreach are widespread to fairly widespread across countries.

Table 9 shows that the most successful forms of Earth science outreach are run by museums in most of the countries surveyed (84%) and that these outreach activities can be very effective; mostly they are effective to fairly effective.

Interactive science centres are available in more than half the countries and are effective to fairly effective. Meanwhile national parks and parks with an Earth science focus are available in around half the countries (national parks – 55%, parks with an Earth science focus – 48%), and are fairly effective.

Networks protecting Earth science sites are available in nearly a third of countries (32%) and are effective to fairly effective.

Table 10 indicates that around a third of the countries have public understanding organisations focussing on Earth science (35%), local “rockhound” groups (39%), groups aimed at children (35%) and

Public Understanding of Science events with Earth science content (32%). In general these strategies are effective to fairly effective and widespread to fairly widespread.

These Earth science outreach strategies are to be applauded, particularly where they are effective and widespread, but clearly need more dissemination and support elsewhere. The most successful programmes recorded across the world are listed in Table 11.

Undergraduate and graduate geoscience education

Table 12 lists the numbers of undergraduate and graduate programmes found in the contributing countries.

The figures, although they range from 1 to perhaps 600 intuitions per country offering undergraduate education and 1 to 336 offering postgraduate education, are not very meaningful. At most they probably show that, the more developed and larger a country, the more institutions offer geoscience at Higher Education level.

In only two countries (Taiwan and Germany for geography) do the geoscience higher education institutions have a role in mentoring school teachers of Earth science. Elsewhere, no such links are recorded.

Major problems facing school-level geoscience education

The open-ended responses to this question were wide, varied and difficult to summarise. They do however, need to be set against recent successes in Australia, Norway and the Philippines. In Norway, the

Table 8. The global availability of optional geoscience education courses (the positive responses are shaded)

Country	Are optional earth science or geoscience courses offered in schools/ colleges?	At what age are they available?	Are they available to all/ most/ a few/ hardly any pupils across the system?	Do earth science/ geoscience courses satisfy college or university science entrance requirements?
Argentina	No			
Australia	Yes	16-18 year olds	Small number	Yes
Bangladesh	No			
Brazil	No, but mining courses and environmental sciences training in some technical colleges	17-19 year olds	Few	No courses but some related questions in exams
Czech Republic	Very rarely	17-19 year olds		
England	Yes	16-18 year olds	Hardly any	Yes
Estonia	No			
France	No			
Germany	Yes (depends on the Federal State)	10-16 year olds	No	No
India	No for schools, Yes for colleges	19 year olds	A few	Yes
Indonesia	Technical High Schools offer Mine and Geology courses	15/16-18/19 year olds (schools)	Only for those who take Technical High School	No
Israel	Yes	16-18 year olds	Few	Yes
Italy	No			
Japan	Yes	15-18 year olds	Only students who want to major in earth science-related studies at university take these elective courses	Around 4% of all students chose earth science I as one of their college entrance exam areas in 2008
Korea	Yes	16-18 year olds	Students who want to major earth science-related studies at the university take these elective courses	Around 17% of all students chose earth science as one of their college entrance exam areas in 2004
Malawi	Yes	After the age of 16	Available to all science students	Yes
New Zealand	Yes, but now very reduced to almost none	Years 11-13	Depends on school	Yes
Norway	Yes	17-19 year olds	Depends on the school	Yes
Philippines	Yes	13+ years	No	No
Portugal	In some professional schools			No
Romania	Yes	11-18 year olds		Yes
Russia	Yes	Secondary school level	Students who want to major Earth science-related studies at the university take elective courses	Not enough
Saudi Arabia	No			
Scotland	Yes	14+	Few	Yes
South Africa	No			
Spain	Yes	16-18 year olds	Only to science branch pupils	Yes
Sri Lanka	No			
Taiwan	Yes	Years 11 and 12		Yes
Trinidad & Tobago	No			
United States	Available in some schools.	Varies	Depends on the school.	Variable. Some universities/ colleges do accept geology others do not.
Uruguay	No			
Total/31	19 = 61%	Mostly 16-18 year olds	Generally small numbers	Mostly 'yes'

Table 9. The availability of Earth science outreach in museums, interactive science centers, national parks, parks with an Earth science focus and networks protecting Earth science sites (the paler the shade, the less effective/widespread – where limited data are available, this is shown in white) (Key: V = very; F = fairly; Ef = effective; Wi = widespread)

Country	Museums	Interactive science centers	National parks	Parks with an Earth Science focus	Networks protecting Earth science sites
Argentina					
Australia	Ef	Wi	F Ef	F Wi	
Bangladesh	One				
Belgium	V Ef	V Wi	V Ef	Wi	
Brazil	V Ef	Wi	Some	F Ef	F Wi
Czech Republic	Ef	Wi		F Ef	Wi
England	Ef	F Wi		Several	Ef
Estonia	Ef	Wi	F Ef	Wi	F Ef
France	Ef	F Wi	Ef	F Wi	F Ef
Germany	F Ef	Wi	F Ef	F Wi	F Ef
India	Some	Ef		Ef	
Indonesia	F Ef	F Wi	Ef	F Wi	F Ef
Israel	F Ef	F Wi	F Ef	F Wi	F Ef
Italy	V Ef	Wi	F Ef	F Wi	F Ef
Japan	Ef	F Wi	Ef	F Wi	F Ef
Korea	V Ef	V Wi	F Ef	F Wi	F Ef
Malawi					
New Zealand	F Ef	F Wi	One	Minimal	One
Norway	F Ef	F Wi		Two	
Portugal		Ef	Wi		
Philippines	Ef		Ef		
Romania	Ef	Wi	F Ef	F Wi	F Ef
Russia	F Ef	F Wi	One		
Saudi Arabia	F Ef	F Wi		Ef	Wi
Scotland	F Ef	F Wi		F Ef	F Wi
South Africa	F Ef	F Wi		Two	Small scale
Sri Lanka	V Ef	Wi	Some		
Spain	V Ef	Wi	V Ef	F Wi	Ef
Taiwan	F Ef	F Wi	F Ef	F Wi	V Ef
Trinidad & Tobago		Ef	Wi		
United States	Ef	Wi	Ef	Wi	Ef
Uruguay	V Ef	V Wi			
Totals/31	26 = 84%	19 = 61%	17 = 55%	15 = 48%	10 = 32%

new optional geoscience courses are proving increasingly popular to 16-18 year olds, whilst recent revamps of the science curriculum in Australia and the Philippines has seen increased content of Earth science at all levels.

Elsewhere, some of the key comments recorded were as follows.

- Lack of support for school-level geoscience education from the science education community (biology, chemistry and physics).
- Lack of support for school-level geoscience education from geoscientists – particularly those in Higher Education.
- The teaching of school geoscience by non-specialist teachers (eg. specialists in geography, chemistry, etc.).
- Earth science being taught in poor, didactic ways with few examples, by non-specialist teachers.
- Lack of Earth science-focussed teacher training.
- Poor Earth science teaching resources.
- Lack of an internationally agreed Earth science curriculum – promoted across the globe.

A summary

The data from the biased sample of the 32 counties included in the survey can be summarised as follows.

- **Curricula** - across the world, Earth science is included in science and geography curricula in a variety of different ways
- **Standards** - most countries have national standards for Earth science
- **Global coverage** – there is fairly good coverage of Earth science in the school curriculum globally – particularly for 7 – 16 year olds

Table 10. The availability of Earth science outreach in Public Understanding organisations focussing on Earth science, local “rockhound” groups, groups aimed at children and Earth science content of local Public Understanding of Science events (the paler the shade, the less effective/widespread – where limited data are available, this is shown in white). (Key: V = very; F = fairly; Ef = effective; Wi = widespread)

Country	Public understanding organizations focusing on Earth science	Local "rockhound" group	Group aimed at children	Earth science content in local Public Understanding of Science Events
Argentina				One
Australia		F Ef	F Wi	
Bangladesh	One			
Belgium				
Brazil				Some
Czech Republic	Magazines		V Wi	
England		Ef	Wi	I national
Estonia				
France	F Ef	F Wi		
Germany				
India	F Ef		F Ef	F Ef
Indonesia	Ef	Wi	Ef	Wi
Israel	F Ef	F Wi	F Ef	F Wi
Italy				Ef
Japan				
Korea	V Ef	V Wi	F Ef	F Wi
Malawi		F Ef		
New Zealand				
Norway	Geol Day		F Ef	F Wi
Portugal				
Philippines	Ef	F Ef	F Ef	V Ef
Romania	F Ef	F Wi	F Ef	F Wi
Russia	Magazine		F Ef	F Wi
Saudi Arabia				Some
Scotland				
South Africa		F Ef	F Wi	Some
Sri Lanka				
Spain				V Ef
Taiwan	Ef	F Wi	V Ef	F Wi
Trinidad & Tobago	Ef	F Wi		
United States	Ef	Wi	Wi	F Ef
Uruguay	V Ef	V Wi	V Ef	V Wi
Totals/31	11 = 35%	12 = 39%	11 = 35%	10 = 32%

- **Textbooks** – more than half the textbooks for elementary students and more than a third of textbooks for high school students are of poor quality or are not available
- **Benchmarking** – a reasonably high number of geoscience terms is included in curricula across the world, with the numbers of terms increasing up the age range.
- **Optional geoscience courses** – these are available in schools/ colleges in more than half the countries surveyed – but mainly for small numbers of 16-18 year olds.
- **Outreach** – Earth science outreach across the globe is variable, with a wide variety of different programmes – however, it is difficult to discern a particular pattern of success
- **Higher Education** – the numbers of courses available to undergraduates and postgraduates appears to depend mainly on the level of development and size of the country concerned.
- **Mentoring** – lecturers in Higher Education institutions very rarely mentor school teachers.

Overall, the data indicates that most global developments in Earth science education at school level have been driven by enthusiastic individuals and groups. This being the case, it is not surprising that global development is very patchy. Nevertheless, a general improvement is probably discernible.

Table 11. Records of successful Earth science outreach programmes across the world

Country	Programme
Argentina	Earth Science Week at the University of Buenos Aires
Bangladesh	<ul style="list-style-type: none"> • Bangladesh National Museum programmes • Mobile educational programmes in some remote areas
Belgium	<ul style="list-style-type: none"> • Exposition “Dinosaures” - Musée des Sciences Naturelles – Bruxelles • Exposition permanente - Musée africain Tervueren • Expositions minéralogiques temporaires
Brazil	“Caminhos Geológicos: Educacao em Geociencias” (“Geology tracks: Geoscience Education”)
France	EDUSISMO LITHOTHEQUE
India	Earth Science Olympiad
Indonesia	<ul style="list-style-type: none"> • Geoscience course for geography teachers conducted by universities, museums or government agencies. • Talks to local government officers and community by universities or government agencies, especially related to the community service programme of each institution.
Israel	The Weizmann’s programme
Italy	<ul style="list-style-type: none"> • Programs during the International Year of Planet Earth (IYPE) • Earth Learning Idea translations
Japan	Natural History Museums and Science Centres developed many programmes.
Korea	<ul style="list-style-type: none"> • Science centres operated by the ‘Science Education and Science Research Institute (SESRI)’ • National science museum/centres located in metropolitan areas
New Zealand	<ul style="list-style-type: none"> • Language of the Rocks • Univ. of Canterbury • Most University outreach programmes • Royal Society initiatives • Te Papa museum programmes
Norway	5 year ‘Geo programme’ sponsored by Statoil http://www.naturfagsenteret.no/c1480828/seksjon.html?tid=1488151
Philippines	National Selection for the International Earth Science Olympiad (IESO)
Portugal	Geology in summer
Romania	National Geographic Competition
Russia	<ul style="list-style-type: none"> • Summer geological school • Geographic Competitions at different levels
South Africa	<ul style="list-style-type: none"> • Cradle of Humankind • Geological Museum at Museum Africa • National Museum Bloemfontein Palaeontology • Origins Centre - University of the Witwatersrand • Sci-Bono Science Centre • University of Bloemfontein/ EarthWise • University of Kwa-Zulu Natal Science Centre • University of Witwatersrand Geosciences Outreach
Spain	<ul style="list-style-type: none"> • Bi-annual meetings’ on earth science teaching (organized by the AEPECT) • Jornadas sobre Didáctica de Biología y Geología • Summer geological trips • Geolodays
Sri Lanka	<ul style="list-style-type: none"> • “Earth science for schools” teacher training workshops organized by Geological Society of Sri Lanka • National Olympiad Competition for school students organized by Geological Society of Sri Lanka and the Department of Geology, University of Peradeniya
United States	<ul style="list-style-type: none"> • Earth Science Week (2nd week of October) sponsored by the American Geological Institute offers many groups suggestions and opportunities to promote the Geosciences. • Many groups and organisations work at local and regional levels to promote geoscience with varying success.

Table 12. Numbers of establishments offering undergraduate and graduate geoscience programmes

Country	How many offer undergraduate degrees in the geosciences or closely related fields?	How many offer geoscience graduate (postgraduate) degrees?
Argentina	14	All of them offer MSc and PhD degrees and orientation courses
Australia	16	16
Bangladesh	3	3
Brazil	34	
England	20	20
Estonia	Yes	Yes
Germany	28	28
India	A few - exact number not known	Several Master courses in different areas of geosciences
Israel	3	3
Italy	29	29
Indonesia	19 (State and Private)	4 (State)
Japan	Many	
Korea	Many	
Malawi	1	1
New Zealand	7	5
Norway	Approximately 9	9
Philippines	5	1
Portugal	Yes	Several Master courses in different areas of geosciences
Russia	36	36
Saudi Arabia	3	2
Scotland	5	5
South Africa	10	10
Spain	10 degrees in geology and 7 mining engineering	All of them offer specific postgraduate programs
Sri Lanka	5	2
Taiwan	30	10
Trinidad & Tobago	1	0
United States	More than 600 institutions "have geology programs, grant geology degrees, or offer geology courses" but not all offer degrees	190 programs that offer Doctorate degrees and 336 programs that offer a Master degree in earth science, geology and environmental science.
27 countries	Range from 1 to perhaps 600; where definite figures are available, mean of 13	Range from 1 to 336; where definite figures are available (excluding US), mean of 10

Despite this, there is no doubt that school-level geoscience education needs more support, in particular:

- the coordinated support of national geoscience communities (for example, by highlighting the contribution of school-level geoscience to undergraduate recruitment – see King, 2011a);
- the support of the international geoscience community;
- the raising of awareness with governments (for example, by highlighting the fact that some of the highest-performing countries in international comparisons in school science have Earth science as a substantial part of the curriculum, for example Japan, Korea and Taiwan (see King, 2011b);
- more resources and infrastructure to fund teacher training in geoscience education, particularly of the science and geography teachers who teach Earth science (eg. see King & Thomas, 2012);
- more resources to fund the development and dissemination of high quality teaching resources;
- better global networking;
- better support for individuals and teams of enthusiasts in different regions and countries seeking to support and enhance the teaching of geoscience in their own communities.

There are success stories in school-level geoscience education across the globe, and these successes need to be celebrated, and the lessons learned from them distilled and disseminated worldwide, through active national and global support networks.

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Table 13. The major problems facing geoscience education (free response)

Country	What do you see as the major problems facing geoscience education in your country?
Bangladesh	<ul style="list-style-type: none"> • Lack of proper education for students to realize the importance of geoscience education and lack of initiative from concerned people i.e., geoscientific community are the major problems. • Moreover, low literacy rates and economic conditions are also problems facing geoscience education in our country.
Estonia	<ul style="list-style-type: none"> • Estonia participated in TIMSS 2003. In geography Estonian students were the best in the world!!!
Germany	<ul style="list-style-type: none"> • The geography curricula emphasize anthropogeography. • The curricula of biology, physics and chemistry barely focus on geoscience topics. • Many geography teachers do not have a sound science education. • The tradition of teaching geoscience topics in geography: very descriptive, quite idiographic, less process-oriented, less connected to biology/ chemistry/ physics.
India	<ul style="list-style-type: none"> • Geoscience marketing is important because the scientific community doesn't realize the applications of geoscience. • Geoscience careers should be made attractive so that the best talent can be attracted. • Massive Funding is required to promote the subject.
Indonesia	<ul style="list-style-type: none"> • The curricula have been changed or modified several times; attention to improving the method of teaching and student creativity seems to have been overlooked in each curriculum modification. • Lack of teachers who can manage all subjects and lack of educational funding exacerbate the education problems. <p>We found the following deficiencies especially in geography:</p> <ul style="list-style-type: none"> • Topics are introduced too early and in too much detail in the elementary school (Year four elementary school). Too much detailed information (but without real examples) make it difficult for pupils to understand. • Some information concerning rock formation and rock classification are not correctly introduced to students. • Lack of real and attractive examples, such as rock samples, slides, CDs, videos, field visits, make this subject un-interesting and rather difficult to understand. • Lack of available funds. • All of the above deficiencies result in poor knowledge, poor understanding and poor appreciation by the public of geoscience. Consequently, when there are any problems concerned with geological hazards, such as landslides, floods, earthquakes, volcanic eruptions, it is hard to warn and protect the public. <p>Some other remarks are:</p> <ul style="list-style-type: none"> • Geoscience marketing is important because the community doesn't realize what geoscience is. • Geoscience knowledge should be taught earlier in schools, beside the applied technology science. • Educate the lecturers in the Universities and government officials on how to transfer geoscientific knowledge to the entire community. • Funds are needed for improving geoscience education for the community.
Israel	<ul style="list-style-type: none"> • Although there have been great effort s and successes with students and teachers, the implementation of earth science education in Israel is still limited. • The main reason for that is the science education establishment. This establishment is influenced strongly by committees of scientists, who actually decide what will be taught in practice in schools. Unfortunately, those committees are composed of scientists from physics, chemistry and biology. No earth scientist takes part in these committees firstly because the leaders of these committees don't allowed this to happen and secondly because of the earth scientists don't fight strongly enough to be included. • As a result, whenever we succeed in raising our profile in schools, these committees respond with new decisions that make teachers to stop teaching earth science.
Korea	<ul style="list-style-type: none"> • There are activities by those active in physics education, chemistry education, and biology education, but not earth science or geo education.
Malawi	<ul style="list-style-type: none"> • Students are not adequately exposed to earth science at an early stage; Earth science as a subject is offered at undergraduate level. This unawareness has led to the students thinking that geography is just the same as earth science. The shortage of earth scientists in Malawi is obvious.
New Zealand	<ul style="list-style-type: none"> • Earth science continues to be a major issue in curriculum design. New Zealand is just beginning a review of the national science curriculum in which earth science makes up the fourth strand. • A key issue is teacher training and the role teacher training establishments play in this. There is no independent earth science department dedicated to training the teaching of earth science. Indeed, the lack of teacher expertise in earth science is a major concern, as is a lack of resources and funding. • There is less focus on inquiry and laboratory investigation for geoscience. Fieldwork has been almost non-existent for some time. • External examination for geoscience has now been removed from Year 11 Science. Very few students nationally engage with geoscience after year 11 (and numbers continue to decline at year 11).

Table 13. *Contd...*

Country	What do you see as the major problems facing geoscience education in your country?
Norway	<ul style="list-style-type: none"> Students choose the optional geoscience course because it is interesting and relevant for their understanding of the news, e.g. earthquakes and extreme weather. The number of students choosing the optional subject is steadily increasing every year. The Norway Center for Science Education has also been contacted by Sweden in order for them to learn about Norwegian geoscience education; we are also in contact with Denmark
Philippines	<ul style="list-style-type: none"> Because of the new K+12 curriculum, we need more educational resources to address the requirements of the curriculum Also because of the new K+12 curriculum, the Teacher Education institutions need restructuring. Specializations must now include Earth Science, among others. But the problem will be the “experts” who will teach the Earth Science subjects.
Russia	<ul style="list-style-type: none"> To provide the baseline standards the Government has established standard curricula for the whole school, “Introduction to the geology” within the subject of geography. However, geology in the standard of geography doesn’t have enough teaching time.
South Africa	<ul style="list-style-type: none"> Geosciences is unlikely to ever be taught as a main subject as there are simply too many competing well established subjects Teacher training is required to strengthen the geosciences component of the subjects they are already teaching Museums out of school informal learning centres need assistance in developing high quality and assessed curriculum related earth science programmes to support teaching in schools Continued interaction with committees responsible for drafting curriculum statements is required so that the curriculum contains (in whatever subject) the essentials knowledge of Geosciences required by every citizen. [Internationally it would help if there could be agreement amongst Geoscience educators about what this knowledge is] At the tertiary level we have difficulty attracting good students into geosciences related fields- good students study medicine, commerce, engineering etc. etc. Weaker students want to do geology because of the prospects of jobs in the mineral industry At the tertiary level we have a problem of retiring academics with few candidates to replace them. Good postgraduates are attracted into industry or to study overseas. With regard to teacher training- few geologists with the job prospects of the mineral industry enter into secondary education or into teacher training- teacher trainers will often therefore, only have primary training in one or another of science disciplines (biology or physical sciences)
Sri Lanka	<p>The main problems in promoting geoscience education in Sri Lanka are:</p> <ul style="list-style-type: none"> geoscience is not taught as a main subject in school curriculum, lack of awareness of geosciences among school students, lack of awareness about geoscience-related job opportunities, shortage of earth science learning materials in schools, etc.
Trinidad & Tobago	<ul style="list-style-type: none"> The high stakes ‘end of primary’ exam only tests math and language skills so many schools opt to teach little or no social studies and science in the two years preceding this exam.

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